
Appendix F

SacEFT Analyses Results

1.1 Background Information

Note: this appendix is **not** a stand-alone document. Context for this material is provided in Section 2.3 of the Sacramento River Ecological Flows Study Final Report (and references therein). Readers are strongly encouraged to read Section 2.3 of the Final Report prior to this appendix.

SacEFT possesses unique strengths that compliment and advance other tools like the Ecosystem Functions Model (EFM) (USACE 2002) and Indicators of Hydrologic Alteration (IHA) (Richter et al. 1996) (Table F-1).

Table F-1. Comparison of SacEFT with related tools for evaluating ecological flow regimes.

	Scale	Ecological Emphasis	Notes
SacEFT	Keswick to Colusa at mixed spatial resolution (index segments, reaches, cross sections) Mainstem only - tributaries not presently included Daily time-step	6 focal species, 35 habitat-centered performance measures links flow, water temperature, gravel augmentation (substrate condition) and channel revetment states with focal species performance <i>Not</i> a predictive salmon life-history model; emphasizes representation of a wide range of ecological processes	<ul style="list-style-type: none"> ▪ A single computer program ▪ Interpretation of biological significance automated through “traffic light” indicator ratings^δ tied to specific biophysical relationships ▪ Emphasizes communication with non-specialists ▪ Builds in non-flow actions for gravel augmentation and channel revetment states ▪ Emphasizes identification of preferred flow, temperature, substrate and channel characteristics rather than precise quantification of focal species life-history outcomes
Ecosystem Function Model (EFM)	Applied reach-by-reach, site specific – not Sacramento River as a whole	15 biological relationships	<ul style="list-style-type: none"> ▪ Links to several other USACE tools through a sequenced analysis & manual interpretation process ▪ GIS map focus ▪ Tightly linked to hydraulic modelling at site scale
Indicators of Hydrologic Alteration (IHA)	Stream gage level data analysis – viable at a reach to segment scale	~32 statistical parameters of hydrologic change (scorecard); no explicit representation of biological outcomes (though IHA parameters known from ecological theory / first principles to be biologically relevant)	<ul style="list-style-type: none"> ▪ Focused on pre- vs. post-alteration comparisons ▪ Does not directly address potential biological significance of hydrologic alterations
DRIFT	Focused on specific index cross sections	Biophysical and socioeconomic consequence data entered as textual statements based on expert opinion, not calculated in a simulation (e.g., “Plants at back of zone under increasing stress; roots unable to develop because of insufficient water”)	<ul style="list-style-type: none"> ▪ Expert system; requires synthesis and interpretation of individual lookup statements ▪ Includes socio-economic considerations

	Scale	Ecological Emphasis	Notes
SALMOD	Keswick Dam to Red Bluff Diversion Dam More attention to meso-habitat characteristics and local hydraulic properties; spatially explicit simulation of movement of cohorts from one habitat unit to another Weekly time-step	Winter, spring, fall and late fall Chinook salmon Model processes include spawning (with redd superimposition), incubation losses (such as redd scour or dewatering), growth (including egg maturation), mortality due to water temperature and other causes. End prediction is Chinook salmon outmigrant abundance	<ul style="list-style-type: none"> Chinook salmon freshwater life history model Parameter intensive, deterministic, predictive model. Tracks spatially distinct cohorts that originate as eggs and grow from one life stage to another as a function of water temperature and flow in a computation unit. Software and data file configuration geared towards expert technical modellers For Chinook salmon, SacEFT uses some of the same source datasets and assumptions as those found in SALMOD

^δ Sometimes referred to synonymously as “hazard ratings” or “severity ratings”.

1.1.1 CALSIM-SRWQM Data Disclaimer

As noted in the Final Report, for the NODOS and Shasta flow scenarios (see Section 1.1.6 for scenario definitions), the daily flow disaggregations *below* Red Bluff Diversion Dam were known to be flawed. Therefore, these modelled flows are used to illustrate contrasting flow regimes for model testing of the sensitivity of the ecological performance measures to the flow patterns. These flows do not represent the actual flows below Red Bluff Diversion Dam following hydrosystem operations with the NODOS or Shasta scenarios. They are for testing and demonstration purposes only. Model results for performance measures calculated at sites *above* Red Bluff Diversion Dam represent legitimate comparisons.

1.1.2 SacEFT: assumptions in underlying physical models

SacEFT includes a variety of physical data sets that originate from several high-profile planning models. The intent is to leverage the extensive existing efforts made in these systems to supply key inputs necessary to calculate focal species performance measures. In addition to these models, select mainstem Sacramento River gauging records have been used for river discharge and water temperatures. Using data from models and stream gauges permits allows multiple prospectives and retrospective analyses. Approximately 66 years of daily historical records were gathered in this manner and used in retrospective (historical) scenarios.

SacEFT prospective daily flow datasets are based on 2005 baseline assumptions as simulated using the CALSIM – SRWQM – HEC5Q modeling complex. The Common Assumptions team has agreed that the daily disaggregation results from SRWQM *below* Red Bluff Diversion Dam are flawed. Hence, it is important to emphasize that in SacEFT, these datasets were used for testing and demonstration purposes. DWR is working on a modified disaggregation algorithm intended to resolve the stability concerns below Red Bluff. The timeline for this updated product is not clear.

Over the course of model development DWR provided several sets of daily disaggregated discharge data for a variety of scenarios. Two of these, “NODOS 2030” (North-of-the-Delta

Offstream Storage) and “Shasta +18.5” were selected. Although both sets of scenarios are preliminary and the daily flow disaggregations below Red Bluff Diversion Dam are flawed, they offered the best opportunity to explore contrasting flow regimes for model testing of the sensitivity of the ecological performance measures to the flow patterns.

Fremont cottonwood initiation is currently the only consideration in SacEFT driving the choice of matched stage-discharge and ground surface elevation data. During our reconnaissance leading up to the model design workshop in December 2005, three sites examined during the 2003 Beehive Bend study (Roberts et al. 2002, Roberts 2003) met our selection criteria:

- RM172
- RM183
- RM192

These sites are assumed to be generally representative of the Colusa to Red Bluff section of the Sacramento River. SacEFT’s riparian initiation submodel is applied to these 3 sites.

Stillwater Sciences has developed The Unified Gravel-Sand (TUGS) model to simulate how bed mobilization and scour affect grain size distribution, including the fraction of sand, of both the surface and subsurface (Appendix E). The model can be used to assess the effects of different management scenarios (e.g., gravel augmentation, flow releases to increase the frequency of bed mobilization and scour, reduction in fine sediment supply) on salmonid spawning habitat. The TUGS model simulates how sediment transport affects grain size distribution, including the fraction of sand, in both the surface and subsurface. SacEFT imports TUGS outputs for use in estimating the benefits of gravel augmentation for spawning WUA.

UC Davis researchers have developed a meander migration model (Larsen 1995, Larsen and Greco 2002, Larsen et al. 2006) using MATLAB software that calculates channel migration using a simplified form of equations for fluid flow and sediment transport developed by Johannesson and Parker (1989). One version of the meander migration model predicts meander migration as a function of a single, representative, geomorphically effective discharge (“characteristic discharge”). The model has been modified to consider the effects of a variable hydrograph on meander migration rates. This is believed to provide a more accurate depiction of the conditions in which meander migration occurs. The underlying hypothesis is that the bank migration rate is linearly related to the sum of the cumulative excess stream power. The meander migration model applied and configured for SacEFT focuses on three river segments located between RM 170-185, RM 185-RM 201, and RM 201-218. The finest unit of resolution of interest in SacEFT is a bend.

Additional details on the assumptions of the meander migration model are available in the Meander Migration Final Report (Appendix D) and on the TUGS Final Report (Appendix E).

1.1.3 SacEFT: matching physical to focal species locations of interest

Each focal species model in SacEFT is designed to accommodate the temporal framework of its input data: daily for flow and temperature and annual for TUGS and MM data. SacEFT accepts inputs that may be point-based (e.g. discharge and temperature) or segment-based (e.g., TUGS data). It links these to inputs to performance measures (PMs) that may themselves be point-based (e.g. GS1 – Green Sturgeon spawning locations) or segment-based (e.g. CS1 – Chinook spawning WUA).

The guiding principle for this linkage is to first fill gaps that may be present in the input data. The second principle is to use the input data that is nearest to the location where the PM is modeled. To do this SacEFT uses the concept of a neighbor zone: any input data located within a user-defined river mile tolerance zone is considered a perfect match. Failing a match within the tolerance zone the nearest upstream data is usually selected. In some cases, such as the riparian initiation submodel, flows are interpolated based on the nearest available upstream and downstream source of flow data for the cross-section of interest.

Some matches require overlaying segment-based data from multiple sources (e.g. TUGS data and salmonid spawning segments). When this occurs, segments that are completely-contained and segments that overlap are weighted by the proportion of their length contained in the common segment. For example, if a short TUGS segment is completely contained in a longer spawning segment along with an adjacent TUGS segment that is half in the spawning segment, the sediment data from the first segment are given a weight of 1.0 and the data from the second segment a weight of 0.5.

In the unique case of salmonid rearing habitat there are some rearing-reaches without spawning and therefore without any natural way to predict the egg-emergence that eventually follows spawning and marks the initiation of rearing. In these cases the average emergence of the *upstream* segments is used to create an egg-emergence distribution for the downstream rearing segment.

1.1.3.1 SacEFT: extending TUGS locations to Chinook and steelhead locations

When applying TUGS data for Chinook and steelhead spawning WUA calculations it was generally necessary to apply annual location-based TUGS results to portions of the river that are outside the area where TUGS was calibrated. In accordance with our nearest-neighbor principle, the predicted substrate composition of the most downstream of the five TUGS simulation segments (near RM 289) was mapped to the downstream segments used by the Chinook and steelhead submodels each year for each of the 6 combinations of 3 flow scenarios and 2 gravel scenarios. In the case of fall Chinook, the most distant segment extends downstream over 70 miles to Vina (RM 218), implying that the distribution of surface substrate size classes (sand through boulder) is comparable across this entire range. It also assumes that gravel injection simulations at upstream locations can be plausibly extended at the downstream locations. The further the spatial extrapolation, the more tenuous this assumption becomes. The solution is to obtain TUGS simulation results calibrated and tested for these more downstream reaches of the Sacramento River.

1.1.4 Assumptions and uncertainties in indicators used in SacEFT

For detailed descriptions of SacEFT's 35 focal species performance measures and their assumptions, readers are referred to ESSA Technologies (2007) (<http://216.21.138.146/SacEFT/help/help.aspx>). Table F-2 summarizes the major assumptions for key focal species' performance measures.

Table F-2. Summary of major assumptions and uncertainties in SacEFT indicators.

Performance measure (and key sub- component(s))	Major assumptions and limitations
Spawning and rearing WUA	<ul style="list-style-type: none"> ▪ The Chinook and steelhead spawning WUA models are based on Mark Gard's habitat preference models (U.S. Fish and Wildlife Service 2003, 2005a, 2005b). Gard's results are based on the River-2D hydrodynamic model. ▪ Inherent Instream Flow Incremental Methodology (IFIM) assumptions, strengths and weaknesses. Habitat suitability curves (weighted useable area vs. discharge) for current velocity, substrate and depth accurately reflect habitat preference and these preferences truly confer differential survival (rather than summarizing a mode of differential selection that has no true significance for survival). ▪ Rearing WUA is not affected by substrate conditions. ▪ Index locations and sampling periods provide a representative snapshot of true habitat conditions and run-type preferences. ▪ The cross-sectional data used to parameterize WUA relationships are a snapshot in time of conditions in the mainstem, and mainstem habitat locations may change slowly or episodically as a result of high flow events, sediment transport and channel migration. Habitat is therefore assumed to be in an equilibrium state in which the spatial arrangement of particular habitats may change, but the segment-wide non-spatial proportions do not. ▪ Habitat preferences for spring Chinook are not available and we assumed they followed those of fall Chinook (Mark Gard, pers. comm.). ▪ Because parameterized relationships were not always available for every desired study location, relationship mapping was carried out by assuming that relationships parameterized for a race or location could be applied to another race or location (Mark Gard, pers. comm.). For example, based on USFWS (1995), the distribution of rearing habitat for spring-run Chinook is almost entirely concentrated below Battle Creek but uses fall-run rearing WUA relationships. Likewise, rearing WUA relationships are not available for downstream from Battle Creek, and currently make use of upstream WUA relationships.
Temperature-salmon egg emergence	<ul style="list-style-type: none"> ▪ Temperature-emergence timing for Chinook/steelhead has been taken from relationships published for the SALMOD model (Bartholow and Heasley 2006). The relationship we adopted is not strictly egg-maturation, but covers the period to free swimming emergence.
Temperature-salmon egg mortality	<ul style="list-style-type: none"> ▪ During the design of SacEFT in 2005 we anticipated using the USBR egg mortality model, but later adopted the mortality ATU models used by SALMOD, since the SALMOD formulation reports and corrects some mathematical errors that may be present in the USBR model.
Chinook/steelhead redd scour	<ul style="list-style-type: none"> ▪ Flows above 20 kCFS trigger a fair hazard (yellow), with flows above 32 kCFS required to trigger a poor indicator rating (red). The model couples these hazard categories to each race's spawning distribution and uses a temperature-driven emergence function to create an aggregated egg distribution for each day of the egg development period. The daily proportion of redds exposed to scour incorporates the joint influence of the original spawning distribution, temperature driven egg-development distribution and the proportion of total spawning WUA available in the river segment.

Performance measure (and key sub- component(s))	Major assumptions and limitations
Chinook/steelhead redd dewatering	<ul style="list-style-type: none"> ▪ The model makes use of Gard's redd dewatering research (U.S. Fish and Wildlife Service 2006b), which estimates proportional decrease in redds over the period between spawning and the emergence of juveniles. Gard's results do not include time explicitly. Rather, his model estimates proportion of spawning redds lost (if any) at each location (l) between the time a day-cohort is spawned (cs) and the end of the cohort's egg development period. Based on discussions with Gard, we adapted this relationship in a way that is mathematically consistent with the original results, but which can be disaggregated to the daily scale of the dewatering model. If there is no decline in flow then no loss occurs. To calculate the daily PM, the model compares the previous day's flow, Q_{d-1}, and the flow on day Q_d. If there is a drop, then some proportion of eggs are potentially dewatered: $f(l, Q_{d-1}, Q_d)$, and bilinear interpolation is used to calculate the loss. <ul style="list-style-type: none"> • Gard's tabular results include fall- and winter-Chinook salmon and steelhead trout only, and relationships for spring- and late-fall Chinook salmon are mapped from fall-run Chinook.
Chinook/steelhead juvenile stranding	<ul style="list-style-type: none"> ▪ The performance measure uses Gard's juvenile stranding research (U.S. Fish and Wildlife Service 2006b) to estimate the proportional decrease in habitat over the period between juvenile emergence and the end of the juvenile residence period. Mark Gard's raw system-level results were disaggregated to the segment level used by SacEFT. As Gard's results do not include time explicitly, we adopted a method that calculates daily losses from the day of emergence through to the end of the residency period. The model compares the previous day's flow, Q_{d-1}, and the flow on day Q_d. If there is a drop, then some proportion of juveniles are potentially stranded: $f(l, Q_{d-1}, Q_d)$, and bilinear interpolation is used to calculate proportional losses between the tabular values found in Gard's tables (U.S. Fish and Wildlife Service 2006b). ▪ Although races are modeled separately in SacEFT, all use a single all-species flow-decline relationship.
Green sturgeon – water temperature tolerances	<ul style="list-style-type: none"> ▪ The impact of water temperature on green sturgeon eggs/larvae is modeled using two temperature breakpoints: 17C and 20C, to mark temperature excursions into zones of moderate and high risk. Each day the model tracks spawned eggs over a fixed development period of 14 days, tracking each spawning day separately. The simplicity of the model stems from the lack of information about temperature-based mortality, referring instead to the categorical evaluation created by Cech et al. (2000, cited in (NMFS 2003)) to assign "healthy", "moderate" and "lethal" outcomes. ▪ Other important measures of green sturgeon life history (e.g., flow-habitat; juvenile entrainment; fishing and poaching, discharge-migration cues and needs) were found to be lacking in quantitative knowledge and therefore are not included in SacEFT.

Performance measure (and key sub-component(s))	Major assumptions and limitations
Bank swallows	<ul style="list-style-type: none"> Because the habitat model is very simplified, it has no memory of flow over time, and the BASW2 indicator does not capture the possible cumulative effects of changes in discharge, nor the role of bank height in predicting bank sloughing. The 'length of newly eroded bank' generated by $L_b = \frac{A}{W}$ using meander migration data does not account well for the depth of bank erosion. Lengths predicted by this formula can also in some cases be artificial, having a trivial depth of erosion along a relatively long length. Soil type is known to be a critical factor in determining whether newly eroded banks are suitable for Bank swallows. The present version of SacEFT does not implement this component of habitat suitability (as this information was not made available to our modeling team).
Fremont cottonwood initiation	<ul style="list-style-type: none"> Standard recruitment box model Sampled cross section nodes, if non-uniform, are representative of the overall cross-sectional characteristics. Tap root growth rate = 29 mm/day Drought tolerance of 2 days (roots can be out of contact with water table for 2 days without being declared dead) Fixed capillary fringe height of 30 cm (a very site specific parameter based on soil type) Cottonwood seedlings whose roots reach a depth of 45cm are assumed to be successful in reaching some type of ephemeral groundwater moisture sufficient to keep them alive through the remainder of their first year (based on dialogue with John Bair, McBain and Trush, pers. comm.). Note: all these assumptions are fully configurable in the SacEFT database.
Western Pond turtles	<ul style="list-style-type: none"> The lack of contrast in meander migration results did not merit calibration and implementation of Western Pond turtles in SacEFT v.1.00.018 (i.e. the key drivers did not vary sufficiently).

Performance measure (and key sub- component(s))	Major assumptions and limitations
Chinook/steelhead: general	<ul style="list-style-type: none"> ▪ The six performance measures are intentionally simplified and generally do not attempt to account for interactions that will naturally occur. For example, redd dewatering, temperature-driven egg mortality and redd scour risk all occur during the incubation period and the processes together would predict a different outcome than each process taken alone. ▪ SacEFT does not track movement of juveniles between reaches, and instead they are assumed to remain in the proportions occurring at the time eggs were spawned. ▪ Lengthening of the egg development and juvenile growth window via lower water temperatures also lengthens the cumulative exposure to other potential mortality sources, a set of processes not accounted for in SacEFT.
Overall	<ul style="list-style-type: none"> ▪ Indicator ratings (“hazard ratings” or “severity ratings”) represent biologically significant thresholds¹.

1.1.5 Methodology for Determining Thresholds: Green -> Yellow -> Red.

Hazard thresholds or indicator ratings (“green”, “yellow”, “red”) are a key feature of SacEFT’s design, and are fully configurable in the SacEFT database. Because these thresholds are assigned at up to 3 different levels of spatial and temporal aggregation (daily, over an entire life history stage and annually) and often include weighting calculations based on life-history distributions and area coverages (spawning WUA), an understanding of these units and scales is essential before changing threshold break-points.

The threshold values used for SacEFT’s initial demonstration are calibrated using a full 66 year historical scenario (1939 – 2004) and then found from tercile break-points (top 1/3 of years “good”, bottom 1/3 “poor”, middle 1/3 “fair”) or obvious shifts in zones of performance following inspection of the all year results. As indicated in meta-data comments provided in the SacEFT database, this approach may under- or over-estimate the biological significance of performance measure results.

The recommended approach for changing thresholds is to have each performance measure reviewed by a small group of knowledgeable and reputable biologists, who form a consensus or majority opinion. Now that the SacEFT prototype is available, such an evaluation is a highly recommended next step.

1.1.6 Water Management Scenarios Evaluated

Scenario 1 (Historical): Historical flows (water year 1939 to 2004).

Scenario 2 (NODOS): The North-of-the-Delta Off Stream Storage Investigation (NODOS) is a California Department of Water Resources and Bureau of Reclamation joint effort looking at the potential to construct a new off-stream reservoir near Maxwell, California.

Scenario 3 (Shasta): The Bureau of Reclamation is investigating the potential of raising Shasta Dam 18.5 feet to increase the reservoirs storage capacity.

Detailed definitions of the 12 simulations performed are provided in the main body of the Final Report (Section 2.3.2).

1.2 Key Questions

Considering that our goal with this work is to facilitate the inclusion of a broader suite of ecological considerations into water planning exercises, we developed a series of questions to test the added value of SacEFT. We formulated the questions to test whether affects of potential water infrastructure projects, and their affects to hydrology and water temperature (as reflected by CALSIM-SRWQM-HEC5Q output) would be revealed through our focal species and associated functional relationships. These “proof of concept” questions were as follows:

Question 1: *Of the 3 flow management scenarios considered in the Study, how much difference do they make to the 6 focal species? Or re-stated, how sensitive are the focal species performance measures to NODOS and Shasta scenarios, relative to historical flows?*

Example 1: green sturgeon egg survival

Focal species performance measures varied in their sensitivity to the 3 alternative flow scenarios considered. An attempt is made to present results in increasing order of sensitivity to flows. Least sensitive was green sturgeon egg survival risk (Figure F-1). In all three scenarios, green sturgeon eggs never encountered water temperatures above 17°C to 20°C during the egg development period.

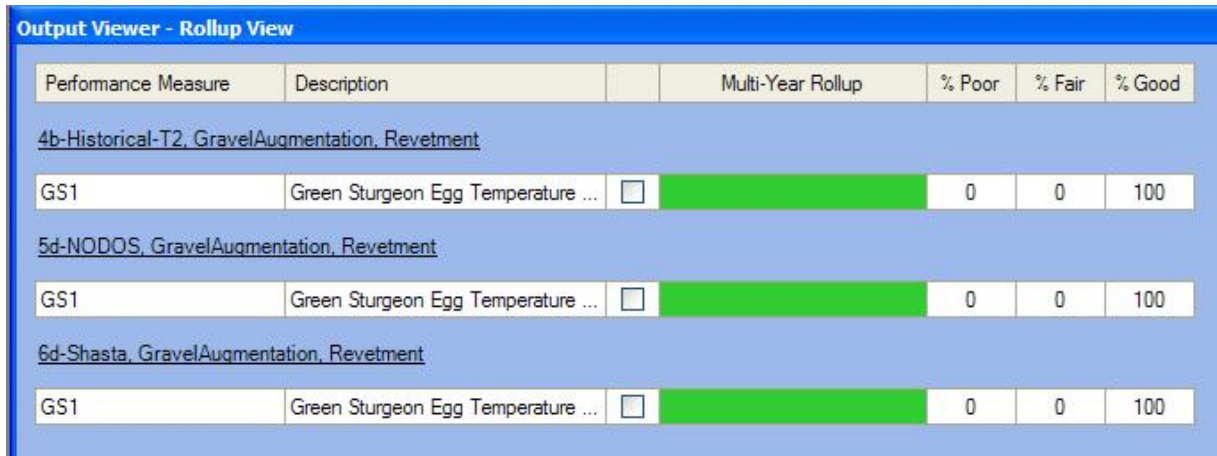


Figure F-1. SacEFT multi-year rollup results for green sturgeon egg survival risk for 3 different flow scenarios.

Example 2: bank swallow length of newly eroded banks

Bank swallow performance measures were also relatively insensitive to the three flow scenarios (Figure F-2). Under NODOS and Shasta scenarios, the incidence of undesirable flows during nesting was reduced. The length of newly eroded banks (BASW1) was largely unchanged amongst these three flow scenarios (Figure F-2).



Figure F-2. SacEFT multi-year rollup results for bank swallow length of newly eroded banks (BASW1) and peak flows during the nesting period (BASW2), for 3 different flow scenarios.

Example 3: Chinook and steelhead redd scour risk

Chinook and steelhead redd scour risk was slightly lower under both NODOS and Shasta scenarios relative to historical flows (Figure F–3). Increased storage capacity reduced the frequency of flow events greater than 20,000 cfs responsible for redd scour. While there was relatively little difference amongst the three flow scenarios, the potential for improving conditions to limit redd scour was relatively high (as indicated by the frequency of poor performing years for some races).

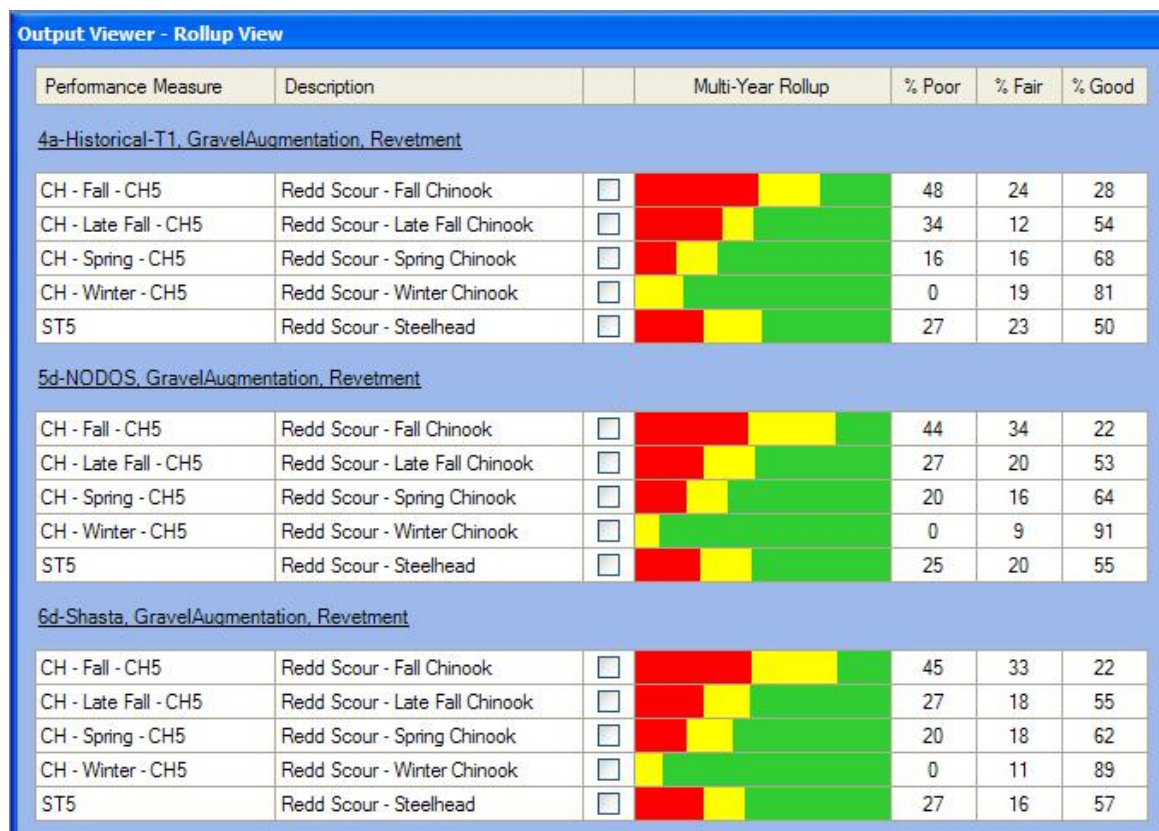


Figure F-3. SacEFT multi-year rollup results for Chinook and steelhead redd scour risk for 3 different flow scenarios.

Example 4: Chinook and steelhead juvenile stranding

Chinook and steelhead juvenile stranding occurred slightly less frequently under NODOS and Shasta scenarios, particularly for spring Chinook (Figure F-4).



Figure F-4. SacEFT multi-year rollup results for Chinook and steelhead juvenile stranding for 3 different flow scenarios.

Example 5: Chinook and steelhead egg-to-fry thermal mortality

Chinook and steelhead egg-to-fry thermal mortality occurred less frequently under NODOS and Shasta scenarios, particularly for spring and fall Chinook (Figure F-5). Lengthening of the egg development window through reduced river temperatures also lengthens the cumulative exposure to other potential mortality sources, a set of processes not accounted for by Figure F-5.

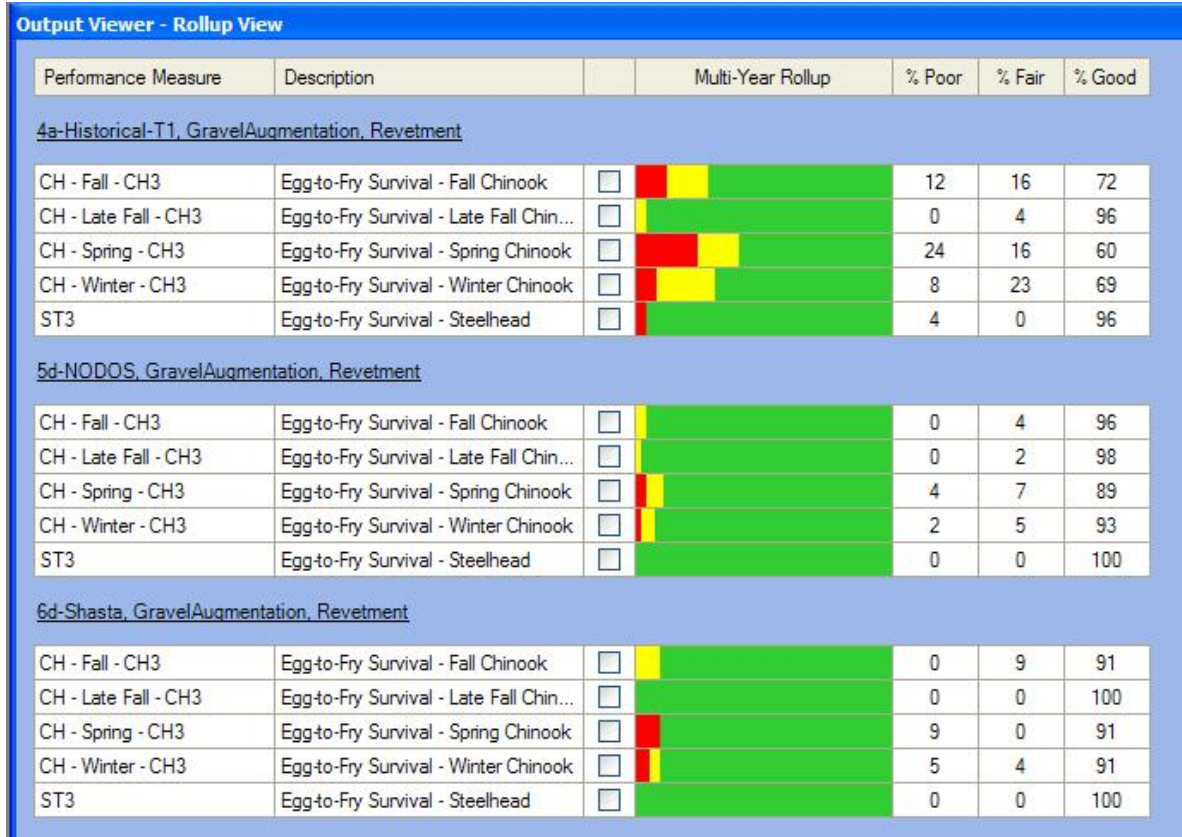


Figure F-5. SacEFT multi-year rollup results for Chinook and steelhead egg-to-fry thermal mortality for 3 different flow scenarios.

Example 6: Chinook and steelhead spawning weighted useable area (WUA)

Spawning weighted useable area (WUA) generally improved for the NODOS and Shasta scenarios relative to historical flows, with the exception of fall Chinook (Figure F.6). In addition, winter Chinook spawning flows were less suitable than historical for the Shasta case. Spawning flows were most improved for steelhead under the NODOS flow scenario.

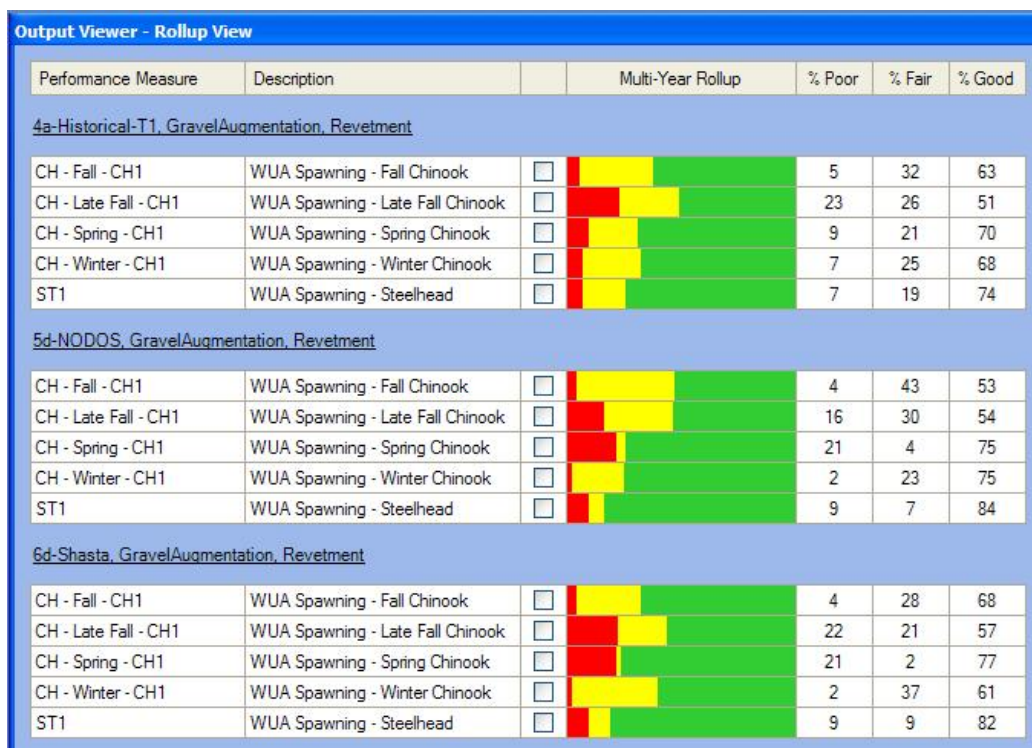


Figure F.6. SacEFT multi-year rollup results for Chinook and steelhead spawning weighted useable area (WUA) for 3 different flow scenarios.

Example 7: Chinook and steelhead redd dewatering

Dewatering of Chinook and steelhead spawning redds worsened under NODOS and Shasta scenarios for fall and winter Chinook, and improved for all other race types (Figure F-7).

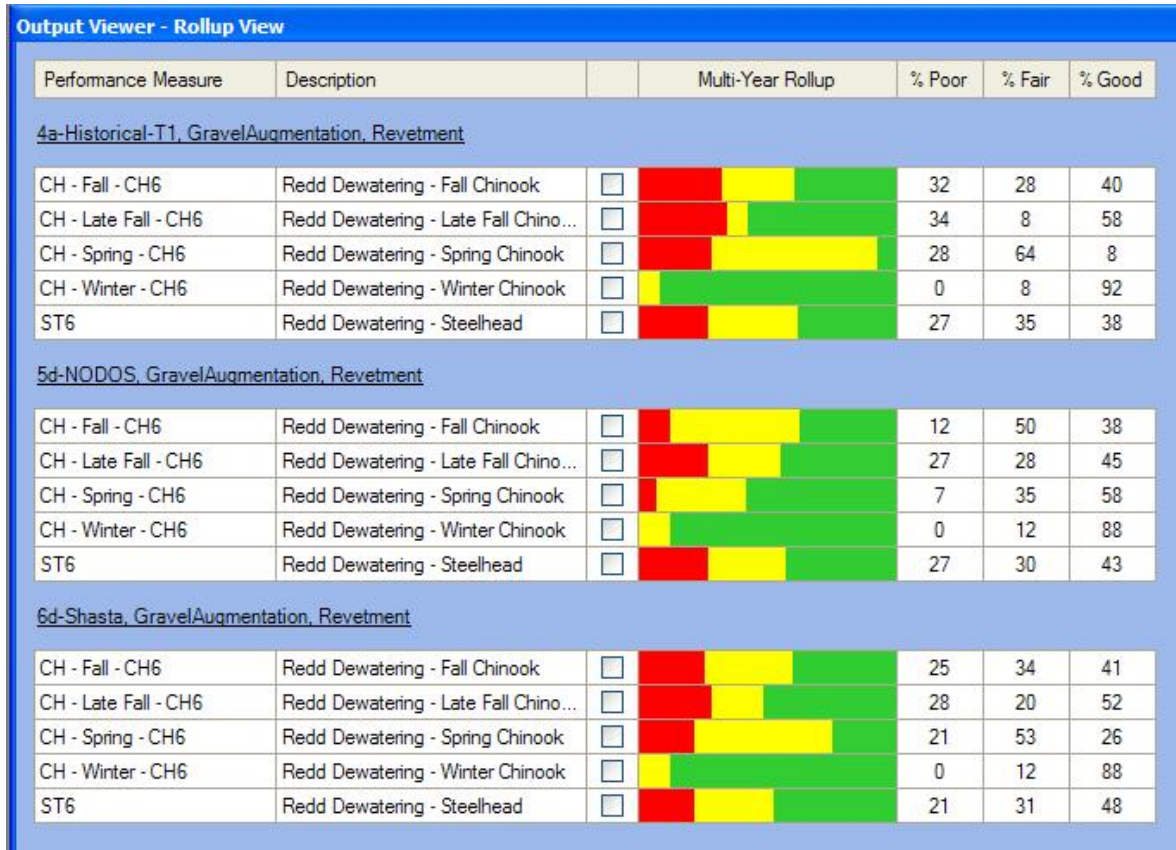


Figure F-7. SacEFT multi-year rollup results for Chinook and steelhead redd dewatering for 3 different flow scenarios.

Example 8: Chinook and steelhead rearing weighted useable area (WUA)

Considering the increased incidence of “fair” year types, WUA rearing generally worsened under NODOS and Shasta scenarios (Figure F–8). A clear exception was late fall Chinook who found more favorable rearing flows under the modified hydrosystem scenario, as to an extent so too did steelhead (Figure F–8).

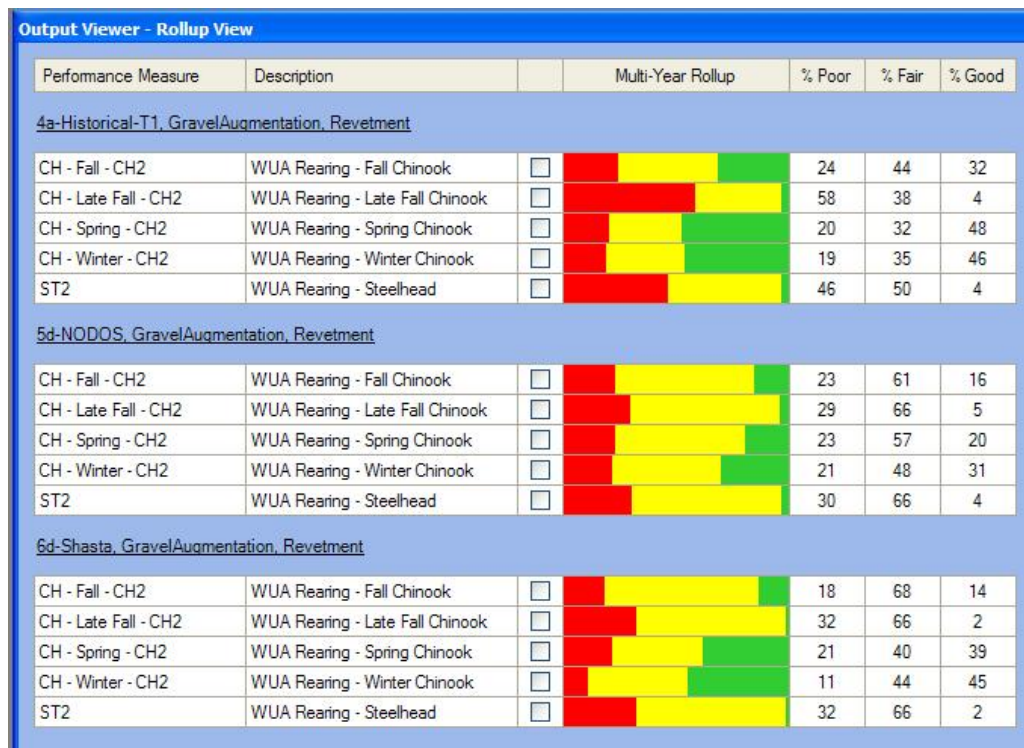


Figure F-8. SacEFT multi-year rollup results for Chinook and steelhead rearing weighted useable area (WUA) for 3 different flow scenarios.

Example 9: Fremont cottonwood initiation success

Fremont cottonwood initiation success was worst for the Shasta scenario, next worse for the NODOS scenario and least poor for historical flows (Figure F-9).

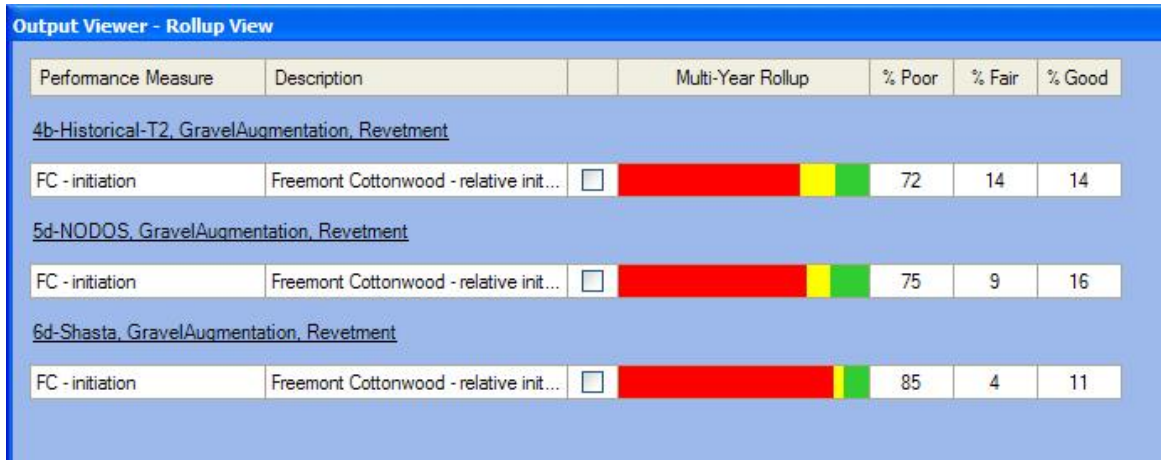
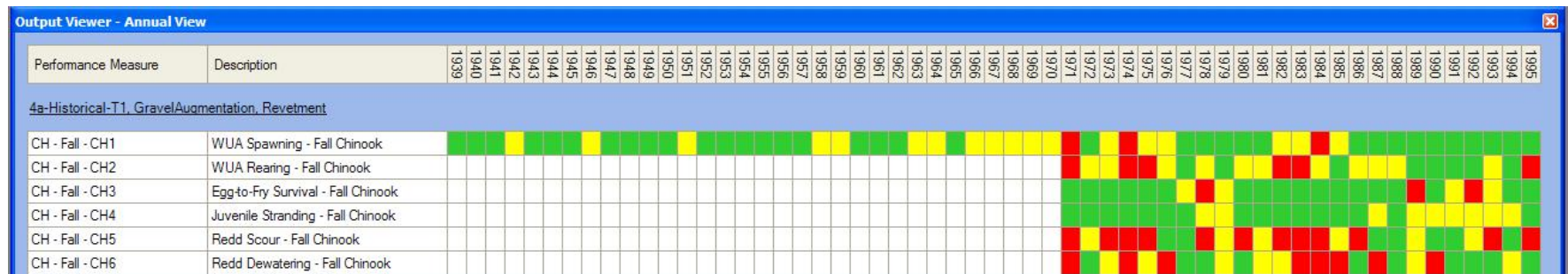


Figure F-9. SacEFT multi-year rollup results for Fremont cottonwood initiation success for 3 different flow scenarios.



Question 1 Summary

Question 2: *How much difference does ‘no channel action’ vs. ‘full channel action’ make? Is gravel augmentation more significant than channel revetment? For what focal species?*

Note: “No channel action” refers to the ‘ng’ and ‘cc’ conditions while ‘g+’ and ‘r³’ refer to “Full channel action” conditions defined in Table 2.3 of the Final Report.

As detailed in the SacEFT design document (ESSA Technologies 2007), 3 performance measures depend on in-channel actions:

Gravel augmentation	Revetment removal and channel migration
Chinook & Steelhead: WUA spawning (CH1)	Bank Swallows: length of newly eroded banks (BASW1)
	Western Pond Turtles: Area of off-channel habitats, indexed by creation of newly orphaned channels (WPT1)

Example 12: Chinook and steelhead spawning weighted useable area (WUA)

Chinook and steelhead WUA (CH1) improved for all races in response to gravel augmentation, especially for steelhead and spring Chinook (Figure F-12). With the exception of steelhead, the improvement in spawning WUA owing to gravel augmentation was muted under NODOS and Shasta scenarios (Figure F-13). Under modified hydrosystem operations, the next greatest improvement in spawning WUA (after steelhead) occurred for winter Chinook. This finding highlights the interaction between flow and substrate conditions that should be taken into account when interpreting WUA predictions. The steelhead finding makes sense, as augmented gravel (g+) includes a relatively high proportion of smaller substrate preferred by steelhead. As substrate preferences are quite similar for Chinook, their spawning WUA performance was more largely driven by flow conditions.



Figure F-12. SacEFT multi-year rollup results for Chinook and steelhead spawning weighted useable area (WUA) for the historical flow scenario, with (bottom) and without (top) gravel augmentation.

Example 13: WUA spawning with and without gravel augmentation for the NODOS and Shasta flow scenarios.



Figure F-13. SacEFT multi-year rollup results for Chinook and steelhead spawning weighted useable area (WUA) for the NODOS and Shasta flow scenarios, with and without gravel augmentation.

Question 2 Summary

In answer to question #2, gravel augmentation was more significant (to Chinook and steelhead spawning) than channel revetment was to bank swallow nesting habitat and western pond turtle habitat creation for the indicators we used. As addressed in question #3 below, in the case of bank swallows and western pond turtles, this may owe to limitations in the physical driving models and simplifying assumptions used for these indicators rather than be a true approximation of what is occurring in nature.

Question 3: *What are the most and least sensitive focal species performance measures? To what actions?*

Table F–3 provides a summary evaluation of least and most sensitive focal species performance measures emerging from the initial application of SacEFT to the scenarios in Section 2.3.2.

Table F–3. Least and most sensitive focal species indicators mapped to SacEFT’s major classes of actions when comparing relative change over scenarios. These results should be interpreted in the context of the flow and channel actions evaluated in the initial pilot application of SacEFT (Table 2.3, Section 2.3.2) rather than as general statements.

Action	Least Sensitive	Most Sensitive
<i>Water temperature</i>	Green sturgeon egg survival risk (GS1)	Chinook and steelhead incubation and early rearing performance measures (lower water temperatures increase period of vulnerability)
	Chinook and steelhead egg-to-fry thermal mortality (CH3)	
<i>Flow</i>	Bank swallows - peak flows during the nesting period (BASW2)	Fremont cottonwood - initiation success (FC)
	Chinook and steelhead juvenile stranding (CH4)	Chinook and steelhead rearing weighted useable area (WUA) (CH2)
	Chinook and steelhead spawning weighted useable area (WUA) (CH1)	Chinook and steelhead redd scour risk (CH5)
	Chinook and steelhead redd dewatering (CH6)	
<i>Rip rap removal (channel migration)</i>	Area of off-channel habitats, indexed by creation of newly orphaned channels (WPT1)*	n/a
	Bank swallow - length of newly eroded banks (BASW1)*	
<i>Gravel augmentation</i>	n/a	Chinook and steelhead spawning WUA (CH1)

* Lack of sensitivity most likely due to simplifying assumptions in indicator formulation or lack of resolution or contrast in incoming meander migration datasets.

The corollary to question 2 is: “*for focal species which appear to be insensitive, is this likely to occur in nature, or does this owe to simplifying assumptions in the SacEFT models?*”

There are two different ways of thinking about this question: (i) in terms of the performance measure results themselves and (ii) more broadly in terms of the overall focal species and its full set of life-history requirements. SacEFT is not a population life-history model, but rather, focuses on discrete habitat-based indicators. As such, component ‘ii’ is outside the scope of SacEFT’s design (though Chinook and steelhead do have multiple indicators that cover different freshwater life-history stages, albeit unlinked). We therefore address this question in terms of component ‘i’ – the contrast and sensitivity found in the results for the performance measures themselves.

The “*” indicators in Table F–3 are most likely insensitive (showed little if any contrast in results) because of simplifying assumptions in the formulation of the indicator in SacEFT or lack of contrast in incoming physical datasets.

For example, the meander migration model provides annual estimates of meander migration rate (W) and area of floodplain reworked (A) for each of up to 14 modeled bends (b) in each of three river segments (Larsen 2007). From these two indicators, the length of newly eroded bank in each bank is approximated by the *simple* geometrical approximation:

$$L_b = \frac{A}{W}$$

Example 14: Average length of newly eroded banks

In BASW1, banks that are newly eroded to 20m or more receive a suitability weighting of ‘1’. The choice of a fairly small length-scale (13m-20m) for assessing the suitability of newly eroded banks is not well matched to the scale at which the Meander Migration model is parameterized: almost all newly eroded bend areas were longer than 500m, and therefore the suitability weight value assigned was almost always 1.0. Coupled with the low variability in year over year lengths of newly eroded bank, this creates a performance measure with very low contrast (Figure F-14).

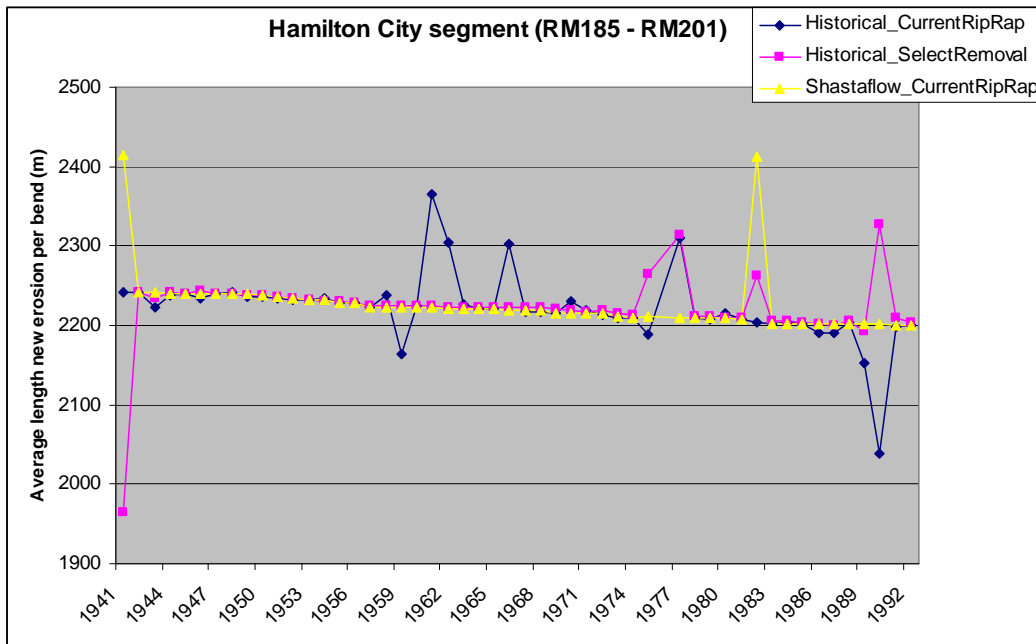


Figure F-14. Average length of newly eroded banks, per bend, predicted by the Meander Migration model, for 3 different scenarios.

We also note that the ‘length of newly eroded bank’ generated by $L_b = \frac{A}{W}$ also does not account for the depth of this bank erosion along the bend. Thus, lengths’ predicted by this formula will in some cases be artificial, having a trivial depth of erosion along the length (<1 cm).

In the case of creation of newly orphaned channels (WPT1), the meander migration model predicted only two events. These occurred in WY 1939 and 1941 only, reshaping Bend 5 of the most-downstream segment (see Table 2.3 in ESSA (2007)) and adding 2070 m² and 425 m² of new orphaned channel habitat in the process. These events occurred under all three flow regimes (historical, NODOS and Shasta) when revetment (rip rap removal) was simulated, and also under the NODOS flow regime when no revetment (no rip rap removal or current rip rap) was simulated.

The fact that the major cut-off event occurred during the first simulation year and across all three flow regimes strongly suggests that the bend morphology became unstable once rip-rap was removed. However, once this event took place, the newly aligned bend and other bends simulated were subsequently insensitive to variations over the following half century of flow variation.

Question 3 Summary

Taken together these results show that simulated revetment removal can cause channel realignment in cases where the bed morphology has reached a point of instability, but that such events are infrequent under the current channel morphology even when rip-rap is removed at select sites. This is not a reflection of lack of sensitivity of the WPT1 indicator itself per se, but reflects the overall lack of contrast in meander migration results.

Finally, we point out that green sturgeon egg survival risk (GS1) was insensitive to the temperatures included in our SacEFT scenarios. Water temperatures that lead to elevated rates of egg mortality in green sturgeon (17°C - 20°C) were rarely if ever encountered for the scenarios we evaluated (including historically reconstructed temperatures) and hence, given the simplicity of the indicator, its results are not in dispute. We recognize that representation of this focal species would benefit from a more complete formulation looking at other life-history stages and biophysical relationships. For example, relations that address flow-habitat; juvenile entrainment; fishing and poaching, discharge-migration cues. These factors were considered during the original SacEFT design workshop, but subsequently found to be lacking in quantitative knowledge for modelling.

Question 4: *Does SacEFT suggest directions for adaptive management experiments and/or research to test the real-world benefits of different actions for focal species?*

At the present stage of development, we do not feel SacEFT is in a suitable position to recommend *specific* adaptive management experiments. Instead, the most important next steps are:

- a. reviewing our focal species indicators for the demonstration scenarios and refining them (including obtaining final NODOS/Shasta daily flow datasets below Redd Bluff),
- b. convening several small technical meetings with qualified biologists to refine the indicator (or hazard) thresholds used to signify the biological significance of different outcomes ('poor', 'fair', 'good'), and
- c. considering whether other focal species indicators (including life-history components) and important biophysical linkages not presently represented in SacEFT should be added based on Linkages Report and Field Study results.

However, even with this important additional review and refinement, residual uncertainties will always remain around various modeling assumptions and parameters. It goes without saying that the proffered biological benefits of SacEFT's target (and avoidance) flows should be tested in the field through focused (preferably high precision) monitoring techniques. However, waiting for perfect or highly certain knowledge ("big proof") is a recipe for inaction that is incompatible with "reasonable and prudent action". Water operators, biologists, restoration ecologists and river engineers should use our findings to experimentally generate purposefully timed contrast in flows, gravel additions, and rip-rap removal actions to better gauge geomorphic and biological significance. "Outside the box" flow and in-channel experiments are critical for generating these fresh insights and overcoming the lethargy inherent in passive approaches.

In the meantime, governors of water operations should not wait to be told that the community of divergent specialties around river restoration have reached a consensus on what should be done. We encourage all sincere water planners, engineers, restoration ecologists and operators to seriously consider the Flows Team's leading hypotheses and advice on ecological flow targets and begin to pilot these flows alongside planned short-term flow experiments and focused monitoring activities. A number of specific ideas in this regard are listed in Chapter 10 of the Linkages Report (Appendix A).

Question 4: Are there any glaring differences with leading hypotheses and management advice identified in the Flows Project Linkages Report?

Table F-4 addresses this sub-question.

Table F-4. Comparison of leading hypotheses and management advice in the Linkages Report (Stillwater Sciences, 2007a) with overall SacEFT modeling results. Details of SacEFT functional relationships are provided in ESSA Technologies (2007).

	Linkages Report	SacEFT*
Chinook/ Steelhead: <i>general</i>	<p>Shasta Dam has generated a cumulative gravel deficit of more than 7.6 million m³ relative to the augmented volumes of 191,000 m³ since 1978. Though patches of favourable spawning gravel from these injections have been helpful, it has done little to expand spawning habitat significantly and reverse the process of bed coarsening.</p> <p>Application of gravel injection in upstream reaches is most effective as that is where the bed is most coarse and where migrating salmon concentrate in highest densities.</p>	<p>Includes performance measures for spawning and rearing weighted useable area, scour, egg desiccation, juvenile stranding and temperature preferences of incubating eggs.</p> <p>SacEFT links gravel augmentation effects to changes in spawning WUA.</p>
Winter-run Chinook	<p>Limited by spawning gravel. Bed coarsening following dam construction (generally true for all Chinook runs).</p> <p>Also identifies reductions in frequency/duration of overbank flows and loss of microhabitats. Juvenile rearing habitat may be the key limiting factor. Inundation of shallow water habitats within the bankfull channel is thought to be of value, so long as it does not lead to stranding.</p> <p>RBDD gate operations that promote upstream migration should remain a top priority to limit predator pit losses by pikeminnow, striped bass and birds in this area.</p> <p>Recommend flows Sep-Oct that inundate shallow water habitats within the bankfull channel (that do not lead to stranding).</p>	<p>Considering historical flow case, rearing WUA for winter run Chinook was not the worst performing relative to other runs (and steelhead). However, rearing WUA was the indicator for winter-run that had the highest count of "poor" rated (red) years (Figure F-15).</p> <p>Winter-run did show improvement in spawning WUA with the addition of spawning gravel, though not as pronounced as steelhead and spring Chinook.</p> <p>After spring Chinook, winter-run exhibited the highest risk of juvenile stranding in SacEFT (Figure F-15).</p> <p>SacEFT does not presently include any components that address RBDD gate operations.</p>

	Linkages Report	SacEFT*
Spring-run Chinook	<p>Shasta Dam cut off access to historical habitat. Dam also eliminated spatial segregation from fall-run Chinook.</p> <p>Due to lack of spatial segregation, fall-run Chinook have the advantage as their eggs are deposited subsequent (and often over top of- spring-run).</p> <p>Hybridization with fall-run has virtually eliminated the spring-run as a distinct run.</p> <p>Spatial segregation from fall-run fish is an important component of restoring spring-run in mainstem Sacramento River. Operation of ACID Dam an important component for realizing this segregation. Without some means to re-constitute the spatial segregation between fall-run and spring-run salmon spawning, the spring-run population is likely to receive little benefit from any restoration or management measures aimed at improving spawning habitat availability.</p>	<p>The effect of spatial segregation on spawning success is not presently included in SacEFT.</p> <p>Of the indicators included in SacEFT, juvenile stranding and redd dewatering were the greatest risk areas (Figure F-15).</p> <p>WUA spawning for spring-Chinook was not noticeably different from levels of success/challenge faced by other run types.</p>
Fall-run Chinook	<p>Largely supported by hatchery supplementation.</p> <p>Life-history strategy of fry emigrating at small size before water temperature stress builds requires prolific egg production and survival of juveniles. Thus, requires abundant spawning habitat. Competition for spawning habitat may be the most likely source of DD mortality (redd superimposition).</p> <p>Recommend flows Feb-Mar that inundate shallow water habitats within the bankfull channel (that do not lead to stranding).</p>	<p>Hatchery vs. wild component of the run not distinguished in SacEFT.</p> <p>Redd superimposition is not presently included in SacEFT.</p> <p>Relative to the other run types, WUA spawning for fall-Chinook was amongst the least challenged (fewest “poor” (red) rated years).</p> <p>Only late-fall Chinook had a lower risk of juvenile stranding than fall-run.</p> <p>Of the indicators included in SacEFT, redd scour was the greatest risk area (Figure F-15).</p>
Late fall-run Chinook	<p>An artifact of Shasta Dam construction and operations. Cold water from Shasta has created over-summering habitat where it did not previously exist.</p> <p>Water temperatures the most significant factor controlling over-summering habitat.</p>	<p>Of the indicators included in SacEFT, rearing WUA was the poorest performing indicator (Figure F-15).</p>

	Linkages Report	SacEFT*
Steelhead	<p>The availability of steep, high-elevation reaches of Sacramento tributaries most important type of habitat, but is unavailable.</p> <p>Biggest limiting factor is the amount of suitable summer and winter rearing habitat for age 1+ and 2+ juveniles. Fry prefer shallow, low-velocity habitats.</p> <p>Velocity refugia to improve overwinter survival.</p> <p>Not as sensitive to spawning gravel limitations because juveniles grow larger and fair better vs. some predators.</p>	<p>Of the indicators included in SacEFT, rearing WUA was the poorest performing indicator (Figure F-15). Redd dewatering was the next indicator to receive the most poor and fair ratings.</p> <p>In terms of spawning WUA, steelhead exhibited the strongest improvement following gravel augmentation.</p>
Green sturgeon	<p>Replacement of Redd Bluff Diversion Dam with a structure that facilitates upstream passage of adults. (Currently mid-May closure of gates may prevent late migrants from accessing preferred upstream spawning sites).</p> <p>Reduce targeted and incidental harvest</p> <p>More research on distribution and spawning preferences – little is known (though present belief is most spawn above RBDD).</p> <p>Current temperature controls (for winter-run Chinook) probably provide a favourable water temperature regime for larvae.</p>	<p>One of the least sensitive indicators in SacEFT.</p> <p>Green sturgeon egg/larvae survival risk (GS1) was insensitive to the temperatures included in our SacEFT scenarios. Water temperatures that lead to elevated rates of egg mortality in green sturgeon (17°C - 20°C) were rarely if ever encountered for the scenarios we evaluated (including historically reconstructed temperatures).</p>
Bank swallow	<p>Bank armoring projects have reduced breeding habitat sites.</p> <p>High flow events during nesting can lead to bank collapse and even inundation which can produce significant mortality. Note: bank swallow nesting coincides with timing of preferred high flows for riparian recruitment.</p> <p>Natural bank erosion is necessary to expose soils that can be excavated by the birds; but this is best if it occurs outside breeding and nesting period. This habitat renewal by erosion is an important benefit of high flow events.</p> <p>Remove rip rap and retire bank armoring in locations where meanders are likely to migrate into soils suitable for nesting colonies. It will be difficult to recover bank swallows without more extensive rip rap removal (~10%-20%). These sites must have appropriate soil conditions.</p>	<p>The length of newly eroded banks (BASW1) that depends on meander migration rate, we did not observe a measureable response whether select rip rap removal was implemented or not. These results were also largely unchanged amongst the three flow scenarios evaluated.</p> <p>Lack of sensitivity in BASW1 most likely due to simplifying assumptions in indicator formulation or lack of resolution or contrast in incoming meander migration datasets.</p> <p>Under NODOS (Sites reservoir) and Shasta + 18.5ft flows, the incidence of undesirable flows during nesting (BASW2) was reduced. In SacEFT, this indicator was more sensitive than BASW1.</p>

	Linkages Report	SacEFT*
Western pond turtle	<p>Loss of off-channel water bodies (through human encroachment and terrestrialization)</p> <p>Hypolimnetic reservoir releases above Redd Bluff may have reduced summer water temperatures too much for WPT.</p> <p>Introduced predators a concern (largemouth bass and bullfrogs)</p> <p>A key potential limiting factor is the relationship between water level and flow in off-channel water bodies during summer incubation. Incubating eggs are extremely sensitive to increased soil moisture. High incubation mortality is likely if summer flows inundate off-channel water bodies. These same flows are beneficial however at other times for driving channel migration and chute-cutoff processes.</p>	<p>SacEFT does not include a relationship addressing flow in off-channel water bodies during summer incubation.</p> <p>In the case of creation of newly orphaned channels (WPT1), the meander migration model predicted only two events. These occurred in WY 1939 and 1941 only and adding 2070 m² and 425 m² of new orphaned channel habitat in the process. These events occurred under all three flow regimes when rip rap removal was simulated, and also under the NODOS flow regime when no rip rap removal was simulated.</p> <p>Taken together these results show that simulated rip rap removal can cause channel realignment in cases where the bed morphology has reached a point of instability, but that such events are infrequent under the current channel morphology even when rip-rap is removed. This is not a reflection of lack of sensitivity of the WPT1 indicator itself per se, but reflects the overall lack of contrast in meander migration results.</p>
Fremont cottonwood	<p>Management of recession limb of hydrograph in wet years to promote seedling establishment. Research by TNC and CDWR suggest that recruitment events may have a recurrence interval on the order of 20 years on the Sacramento River. The recurrence interval for riparian vegetation recruitment on many other similar western rivers is order 5 years.</p> <p>Recruitment flows are not necessary every year, but instead need occur once every 5 to 10 years.</p> <p>Recruitment flow should be in the range of 22,000 to 37,000 cfs during the peak of the cottonwood seed release period (end Apr-beginning June).</p> <p>Promotion of channel migration to create new seedbeds through scour and fine sediment deposition.</p> <p>Control of invasive plant species</p>	<p>SacEFT's riparian initiation model does not consider channel migration, floodplain fine sediment deposition, nor succession.</p> <p>For historical flows, SacEFT predicts approximately 9-10 'significant' recruitment events in 65 years. Approximately 4 in 65 years if successful recruitment events require a normal to wet year in the year following an acceptable recession limb.</p> <p>For good (green) rated years in SacEFT, the recruitment flow (measured at Hamilton City) between Apr-14 and May-15 averaged 20,000 cfs, and ranged between 40,000 cfs and 15,000 cfs.</p>

	Linkages Report	SacEFT*
Geomorphic processes: <i>general</i>	<p>Implementation of the meander zone concept is advocated. River migration critical to the formation and preservation of off-channel habitats as well as exchange of sediment from the channel to the floodplain. Migration is fundamental to formation of numerous types of habitats that are critical for multiple species.</p> <p>Gravel augmentation will be required indefinitely, because surface coarsening and downstream transport will remove injected gravels that cannot be replaced naturally due to the sediment supply deficit caused by Shasta Dam.</p> <p>Gravel bed restructuring to remove coarse surface layer should accompany gravel augmentation. This approach is however very labour intensive.</p>	<p>Gravel augmentation was more significant (to Chinook and steelhead spawning) than channel revetment was to bank swallow nesting habitat and western pond turtle habitat creation for the indicators we used.</p> <p>In the case of bank swallows and western pond turtles, this may owe to limitations in the physical driving models and simplifying assumptions used for these indicators rather than be a true approximation of what is occurring in nature.</p>
Flow management: <i>general</i>	<p>Well-timed spring pulse flows that reconnect seasonally inundated habitats with the mainstem increase habitat area and quality. These flows are desirable so long as they do not lead to stranding juvenile salmonids.</p> <p>Use ACID Dam to re-distribute salmonid spawning if redd superimposition is found to be a limiting factor.</p>	<p>SacEFT uses USFWS stranding site survey data. Used vs. historical flow data, this survey information suggests that spring and winter Chinook experience the highest risk of stranding (Figure F-15).</p> <p>We present a number of specific target and avoidance flows in Section 2.3.4 of the Final Report.</p>

* All statements based on the historical flow scenario, unless indicated otherwise.





















Output Viewer - Rollup View						
Performance Measure	Description		Multi-Year Rollup	% Poor	% Fair	% Good
<u>1a-Historical-T1, NoGravelAugmentation, NoRevetment</u>						
CH - Fall - CH1	WUA Spawning - Fall Chinook	<input type="checkbox"/>		5	39	56
CH - Fall - CH3	Egg-to-Fry Survival - Fall Chinook	<input type="checkbox"/>		9	16	75
CH - Fall - CH4	Juvenile Stranding - Fall Chinook	<input type="checkbox"/>		0	31	69
CH - Fall - CH5	Redd Scour - Fall Chinook	<input type="checkbox"/>		55	19	26
CH - Fall - CH6	Redd Dewatering - Fall Chinook	<input type="checkbox"/>		28	34	38
CH - Late Fall - CH1	WUA Spawning - Late Fall Chinook	<input type="checkbox"/>		23	35	42
CH - Late Fall - CH2	WUA Rearing - Late Fall Chinook	<input type="checkbox"/>		66	31	3
CH - Late Fall - CH3	Egg-to-Fry Survival - Late Fall Chin...	<input type="checkbox"/>		0	3	97
CH - Late Fall - CH4	Juvenile Stranding - Late Fall Chin...	<input type="checkbox"/>		0	0	100
CH - Late Fall - CH5	Redd Scour - Late Fall Chinook	<input type="checkbox"/>		42	13	45
CH - Late Fall - CH6	Redd Dewatering - Late Fall Chino...	<input type="checkbox"/>		34	16	50
CH - Spring - CH1	WUA Spawning - Spring Chinook	<input type="checkbox"/>		16	27	57
CH - Spring - CH2	WUA Rearing - Spring Chinook	<input type="checkbox"/>		19	40	41
CH - Spring - CH3	Egg-to-Fry Survival - Spring Chinook	<input type="checkbox"/>		19	16	65
CH - Spring - CH4	Juvenile Stranding - Spring Chinook	<input type="checkbox"/>		28	56	16
CH - Spring - CH5	Redd Scour - Spring Chinook	<input type="checkbox"/>		16	19	65
CH - Spring - CH6	Redd Dewatering - Spring Chinook	<input type="checkbox"/>		28	63	9
CH - Winter - CH1	WUA Spawning - Winter Chinook	<input type="checkbox"/>		15	33	52
CH - Winter - CH2	WUA Rearing - Winter Chinook	<input type="checkbox"/>		19	40	41
CH - Winter - CH3	Egg-to-Fry Survival - Winter Chinook	<input type="checkbox"/>		6	19	75
CH - Winter - CH4	Juvenile Stranding - Winter Chinook	<input type="checkbox"/>		3	56	41
CH - Winter - CH5	Redd Scour - Winter Chinook	<input type="checkbox"/>		0	19	81
CH - Winter - CH6	Redd Dewatering - Winter Chinook	<input type="checkbox"/>		0	9	91
ST1	WUA Spawning - Steelhead	<input type="checkbox"/>		21	41	38
ST2	WUA Rearing - Steelhead	<input type="checkbox"/>		53	44	3
ST3	Egg-to-Fry Survival - Steelhead	<input type="checkbox"/>		3	0	97
ST4	Juvenile Stranding - Steelhead	<input type="checkbox"/>		0	41	59
ST5	Redd Scour - Steelhead	<input type="checkbox"/>		34	22	44
ST6	Redd Dewatering - Steelhead	<input type="checkbox"/>		33	30	37

Figure F-15. SacEFT results for all Chinook and steelhead performance measures, for historical flows and water temperatures (without gravel augmentation).

1.3 Examples of Within Year (Daily) SacEFT Results

MS Excel graphs and tables serve as the primary output format for SacEFT's detailed within year results. An example of SacEFT's spawning weighted useable area report (WUA) is given in Figure .

Example 15: SacEFT's spawning weighted useable area (WUA) report

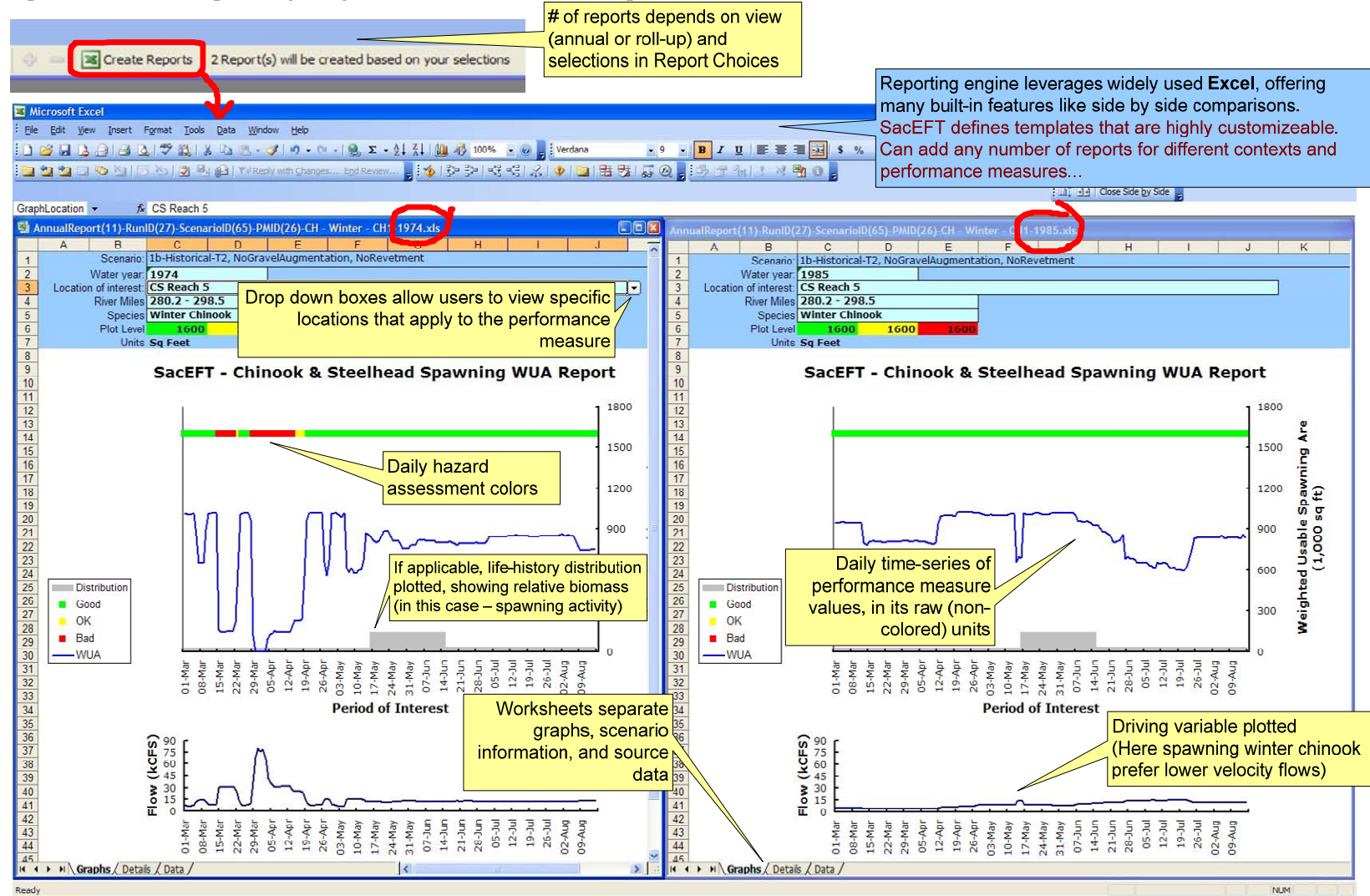


Figure F-16. SacEFT provides detailed output on a scenario × year × performance measure basis in Excel. Here, managers and scientists can examine the detailed results in the performance measure's raw units, alongside its driving variable (e.g., flows).

Example 16: SacEFT's redd dewatering report comparing a good year and a poor rated year

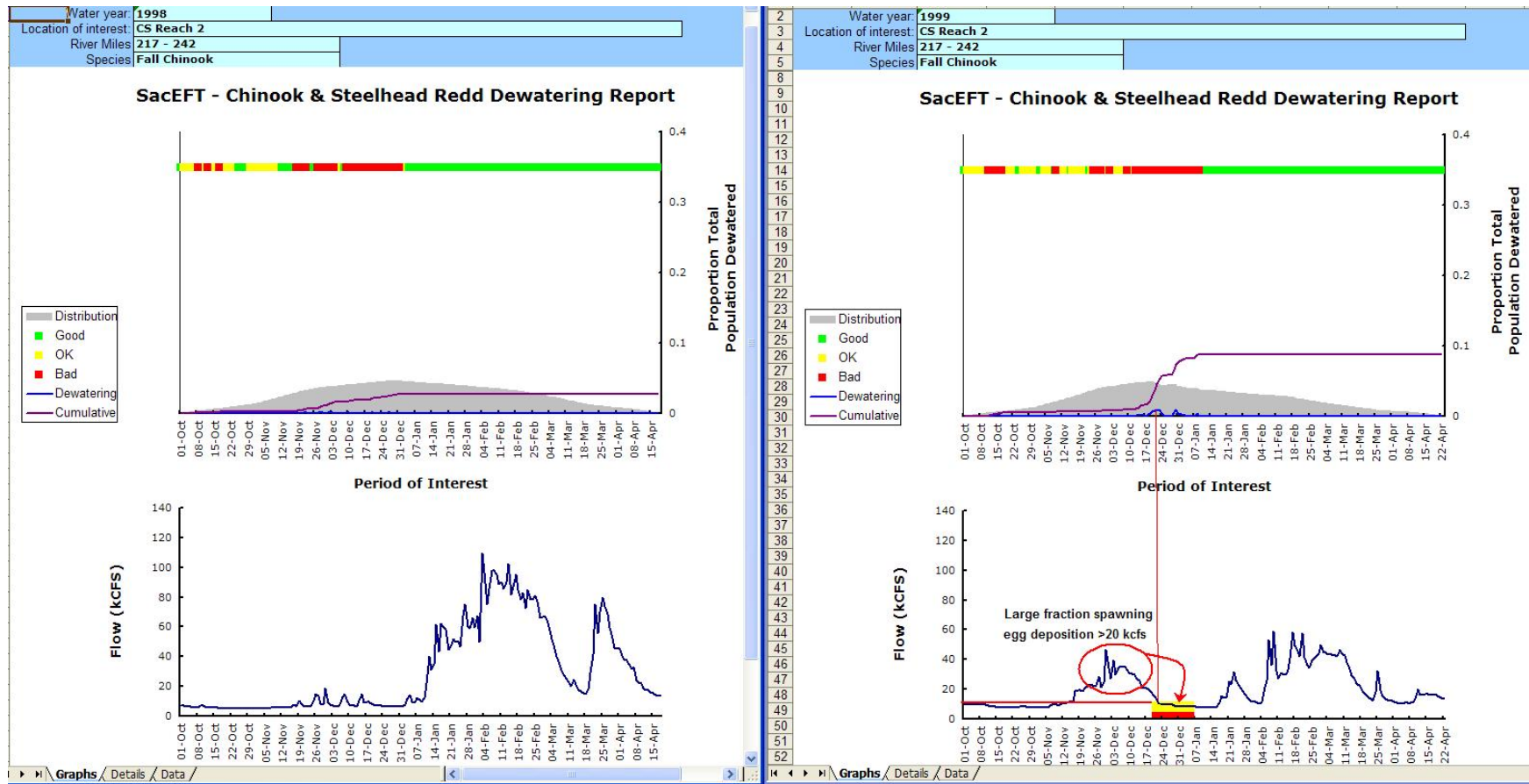


Figure F-17. An example of SacEFT's redd dewatering report comparing a good rated year (left) with a poor rated year (right).

Example 17: SacEFT's juvenile stranding report comparing a good rated year with a poor rated year

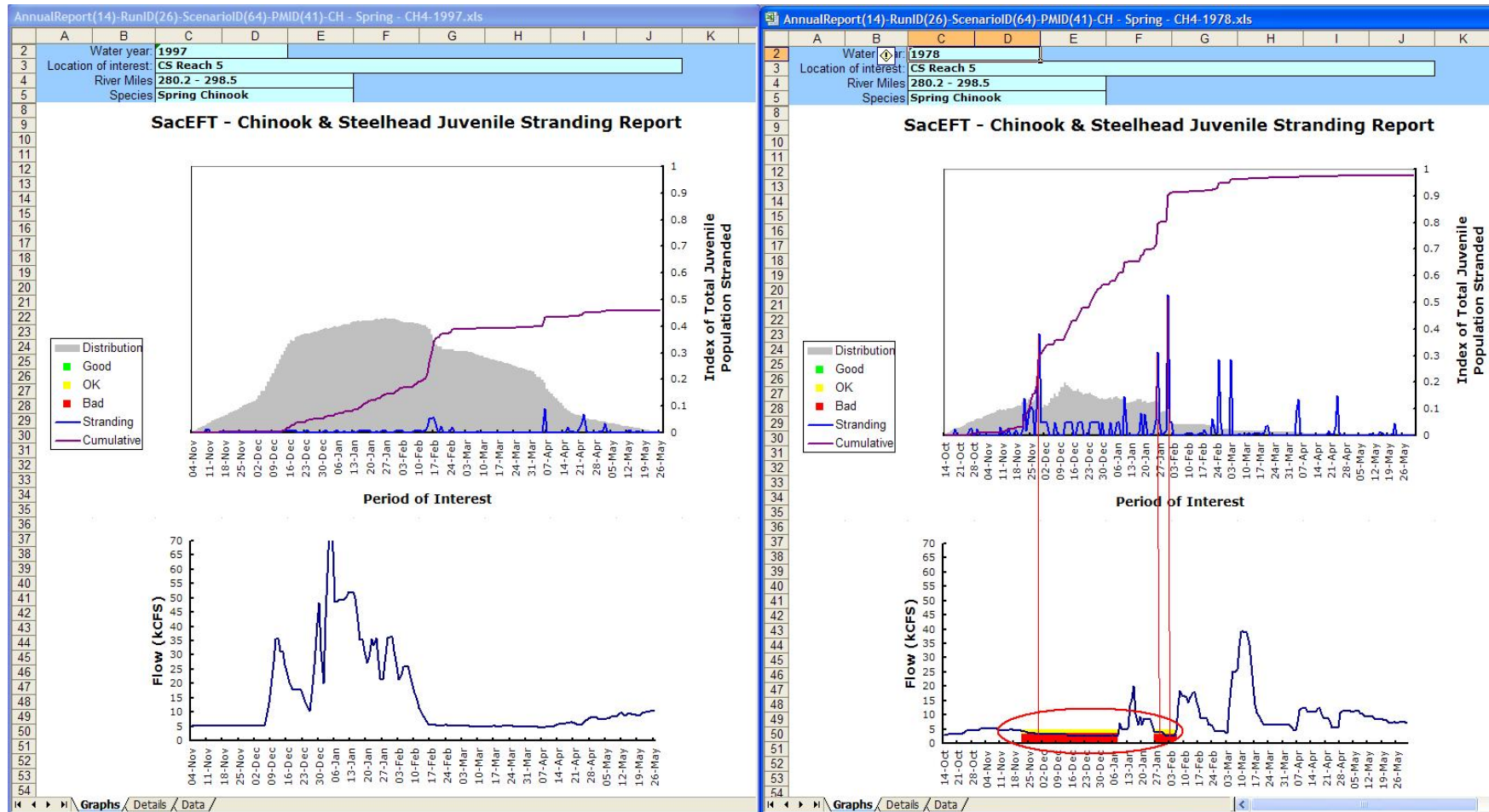
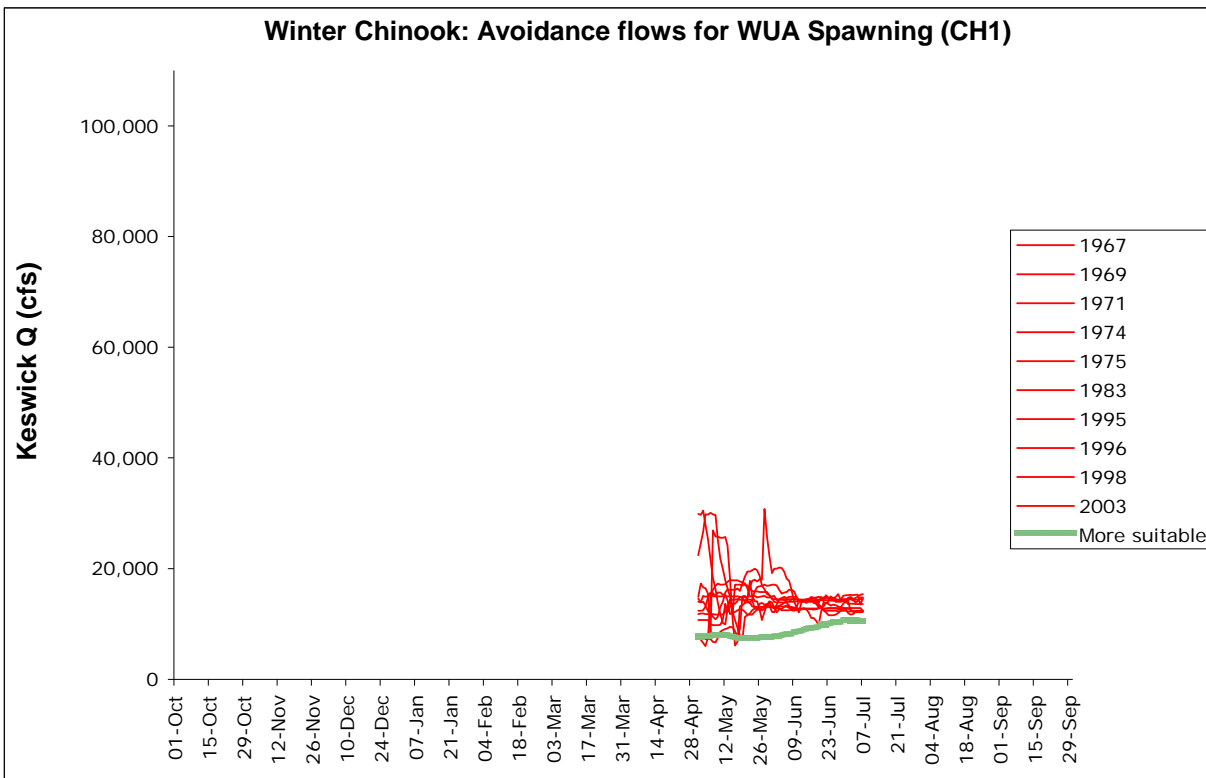
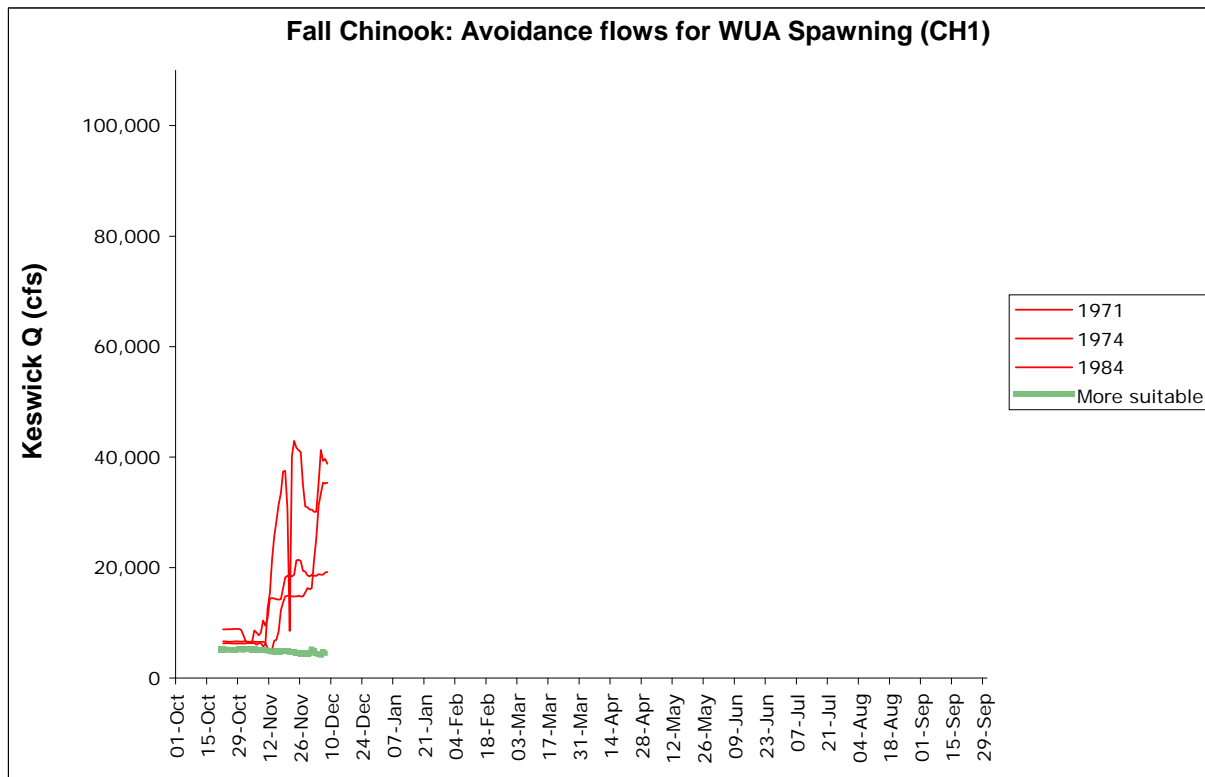
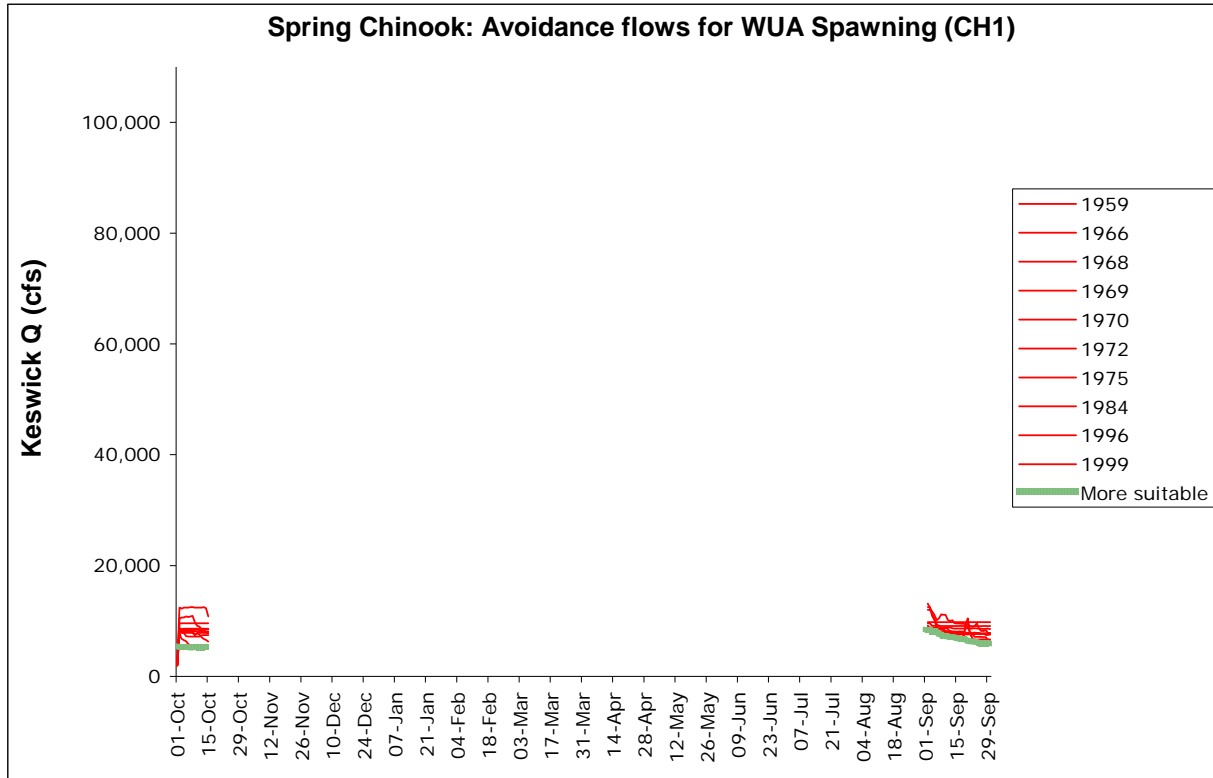


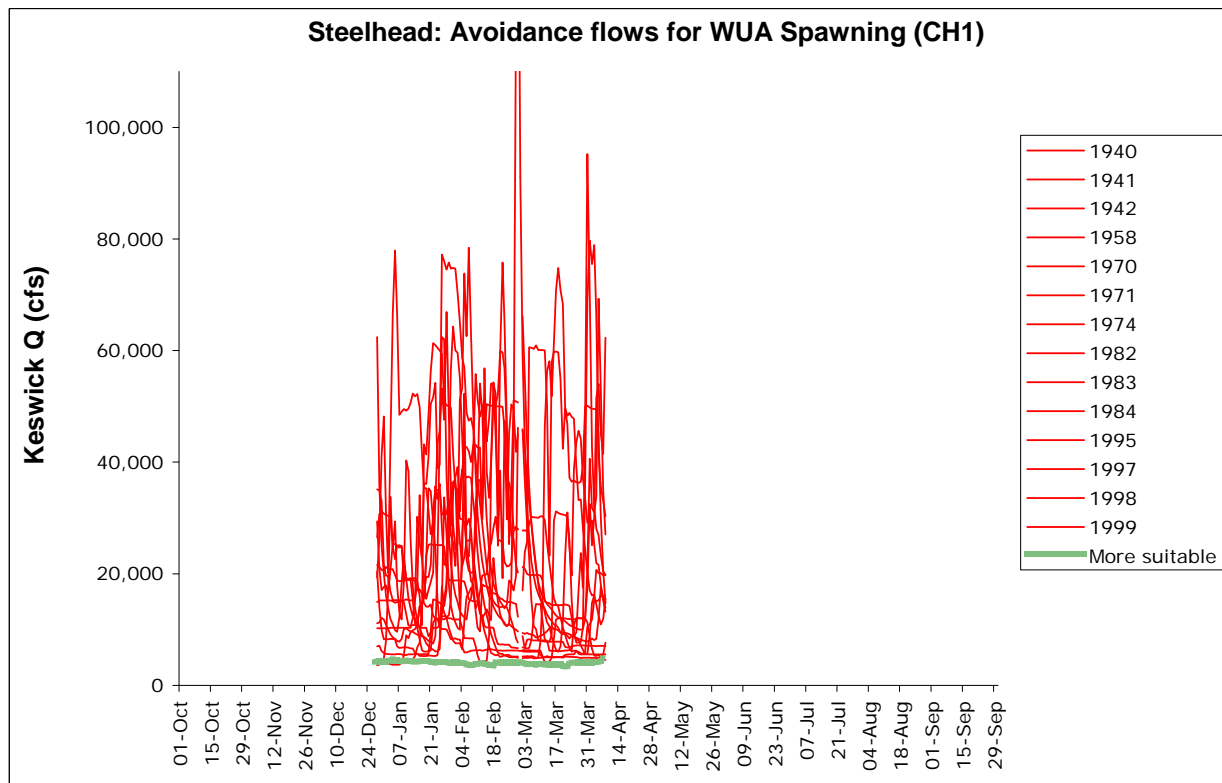
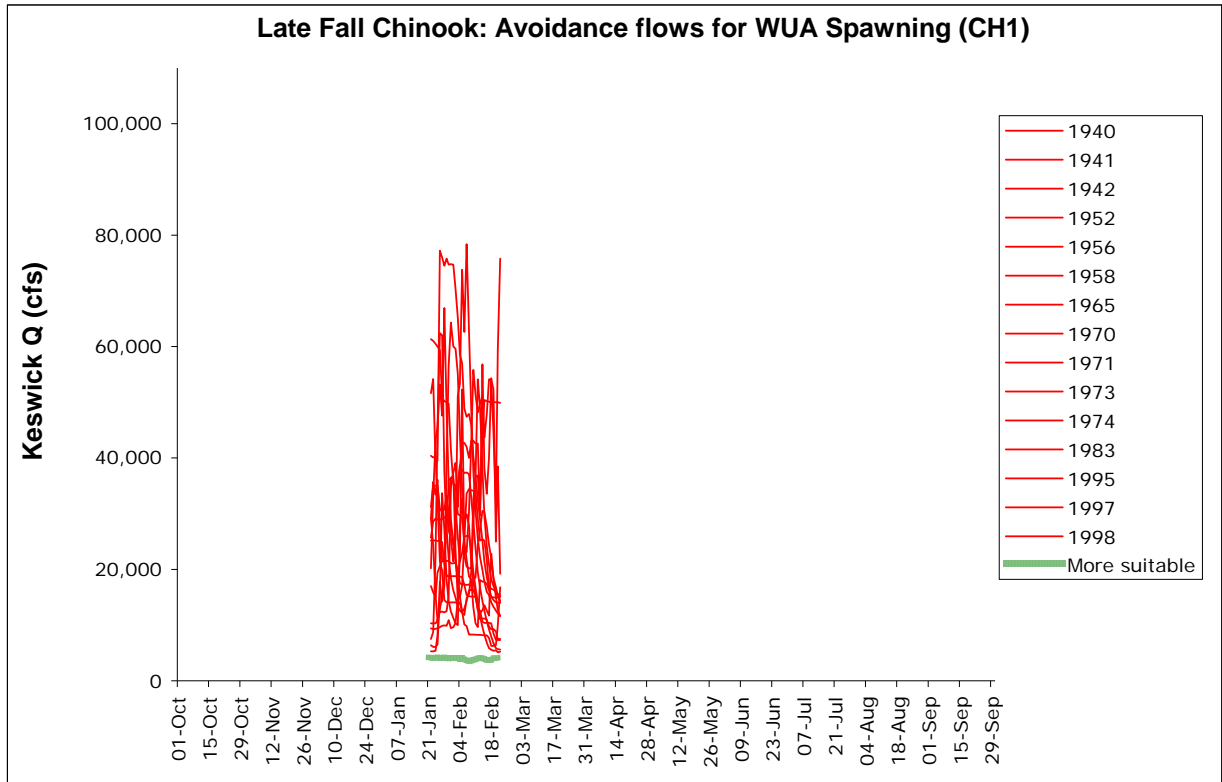
Figure F-18. An example of SacEFT's juvenile stranding report comparing a good rated year (left) with a poor rated year (right).

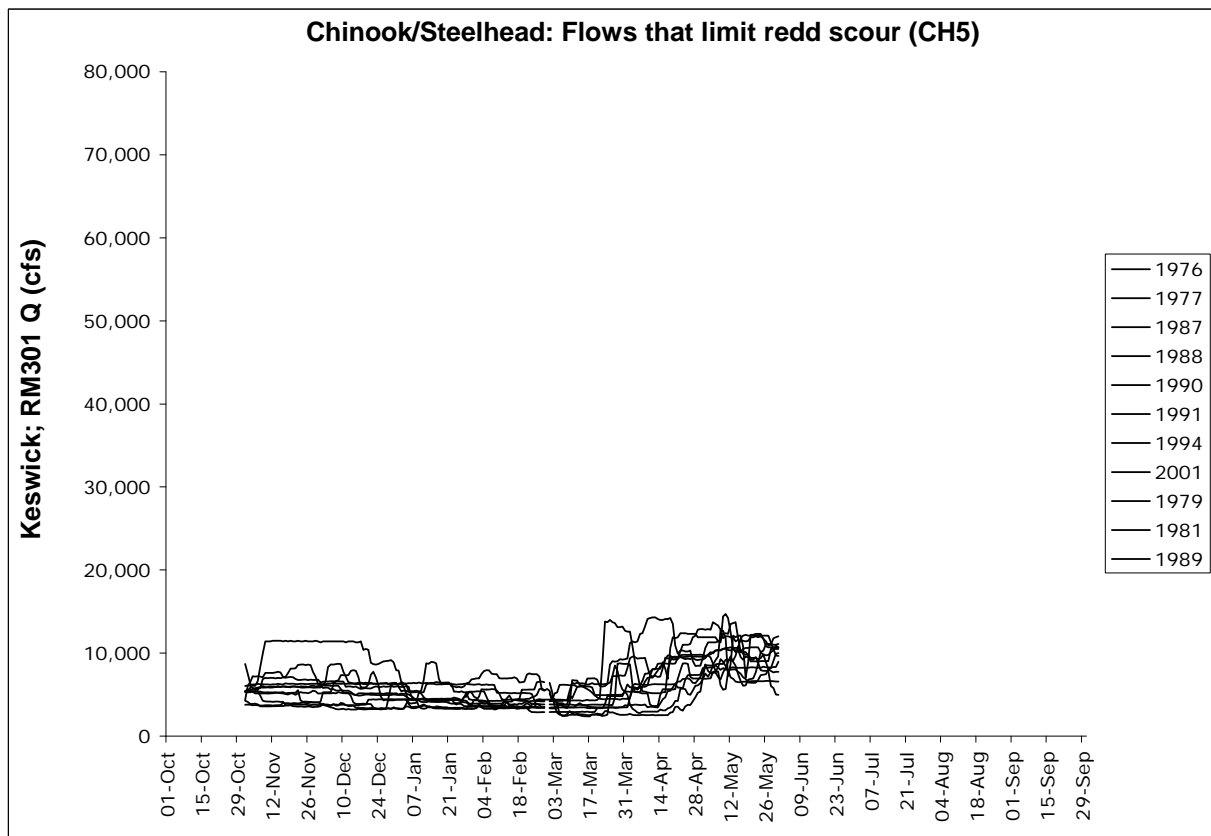
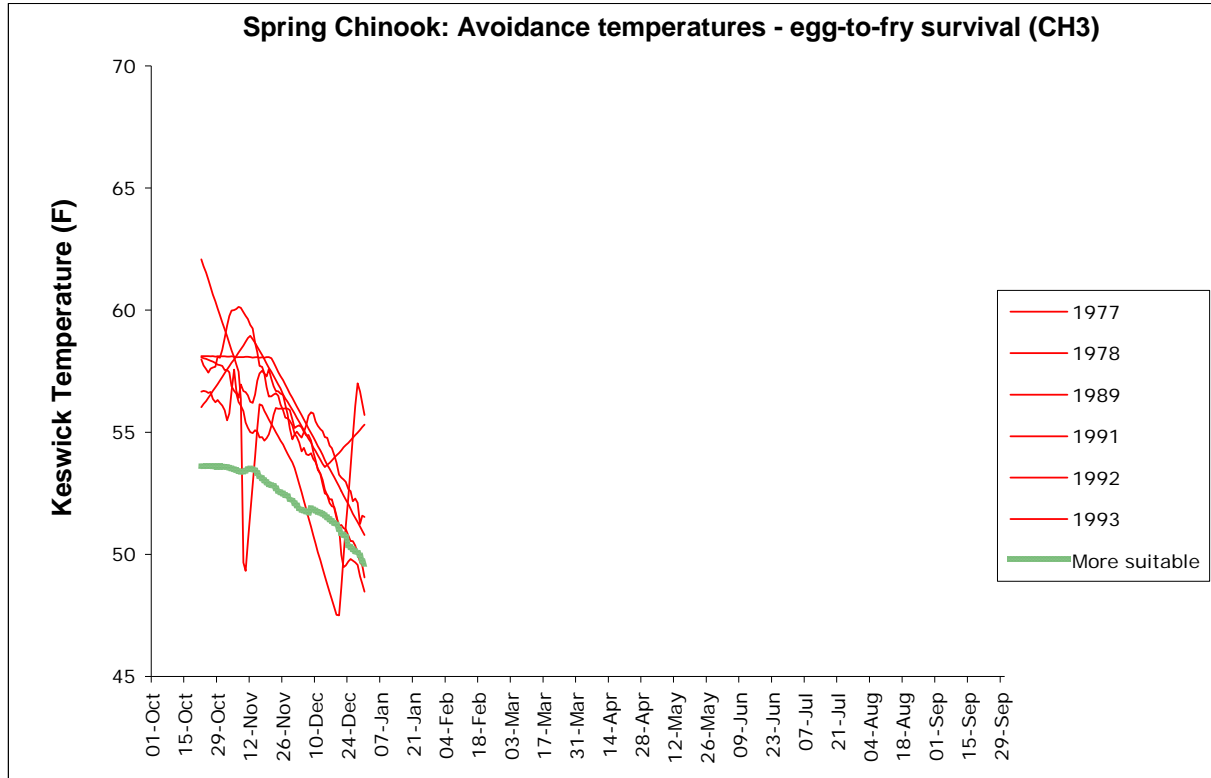
1.4 SacEFT's recommended target and avoidance flow ranges (zoom magnification)

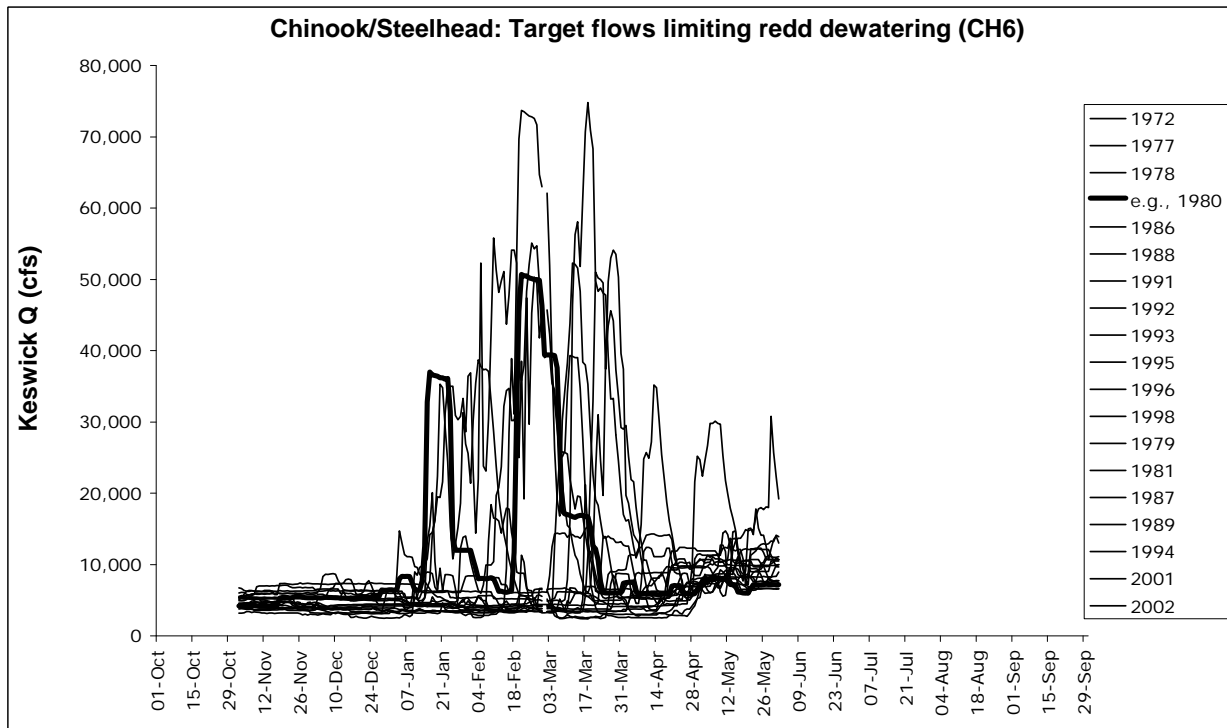
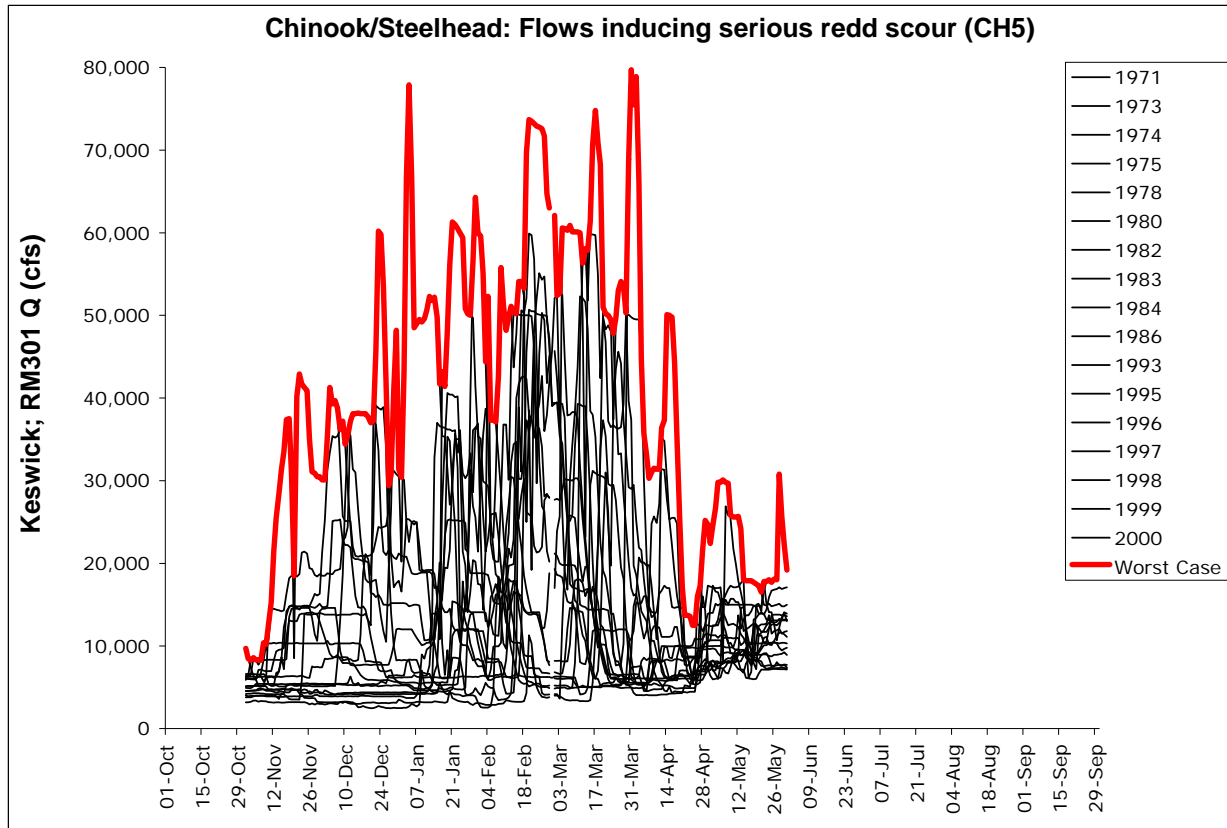
This section provides the same information as that given in Figure 2–1 of the Final Report, but at 'zoom' magnification for individual focal species (and where relevant, Chinook run-types). These target and avoidance flows were derived by taking the historical flow scenario (water years 1939-2004), run ID 26, and selecting all the good (green) performing years ('target' or 'desired' flow) or poor (red) performing years ('avoidance' flow). "More suitable" flow lines represent the median of all good (green) performing years found in the historical model simulation. Given this approach, some "target" flows for some Chinook run types may in reality reflect the "least worst" flows observed historically rather than a true target flow.

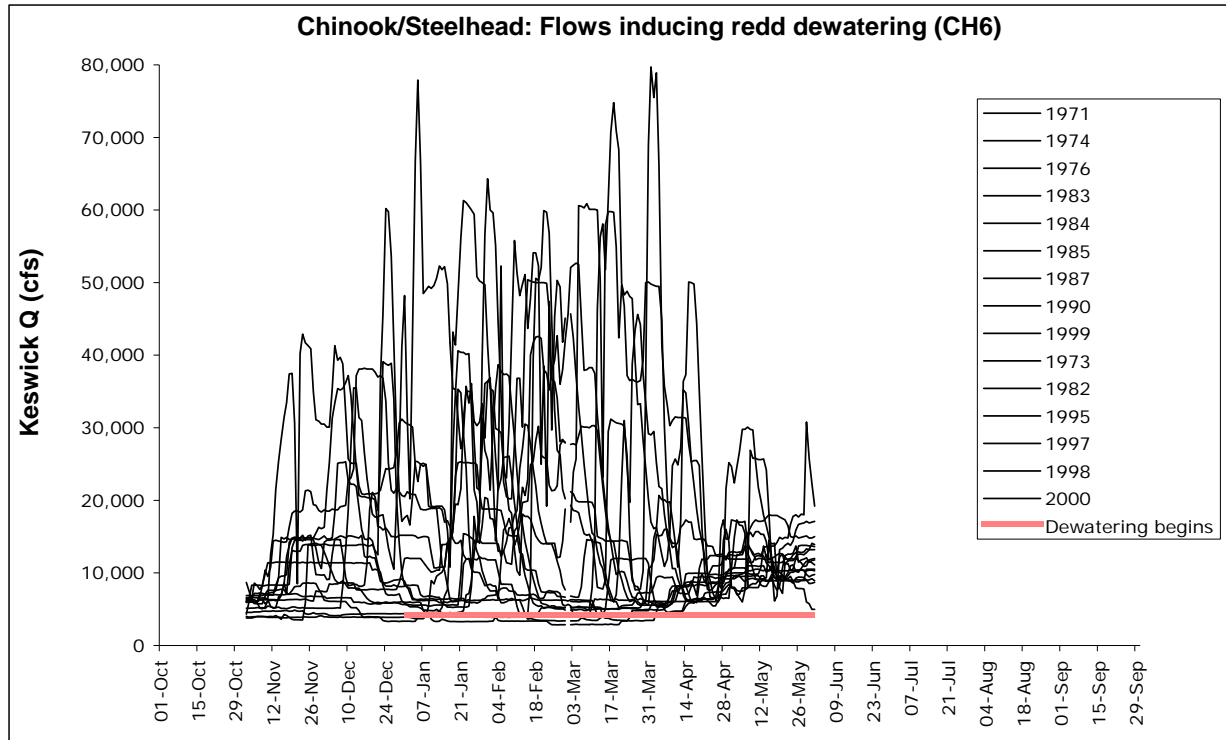




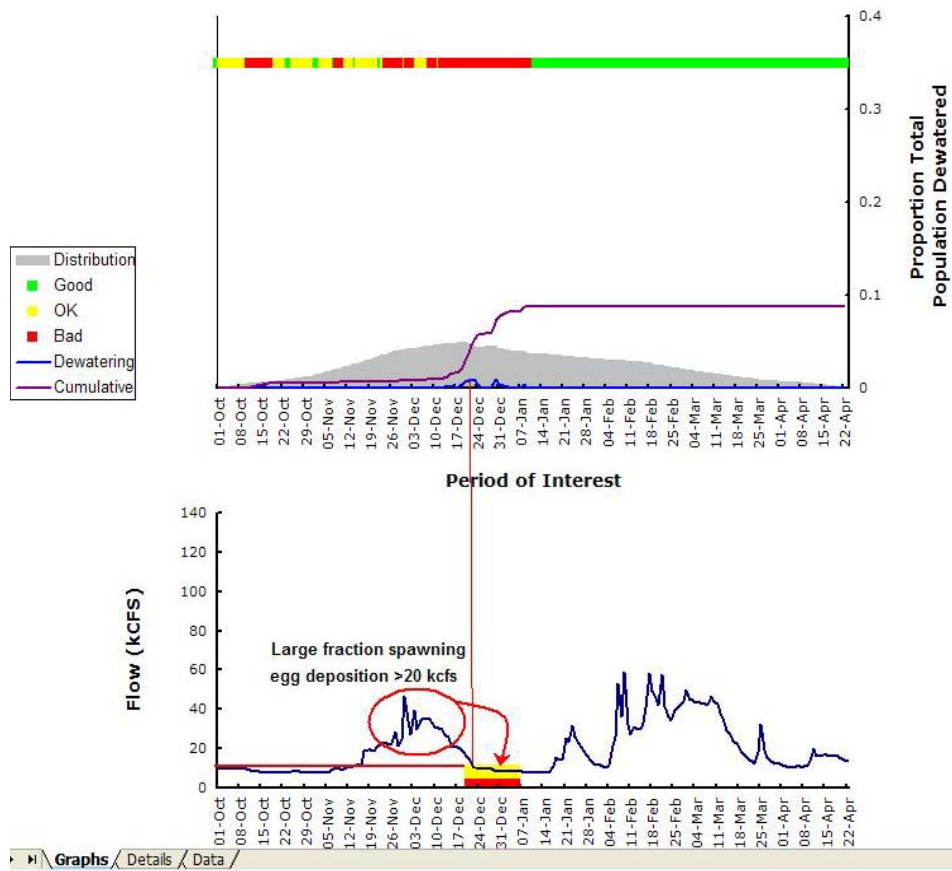


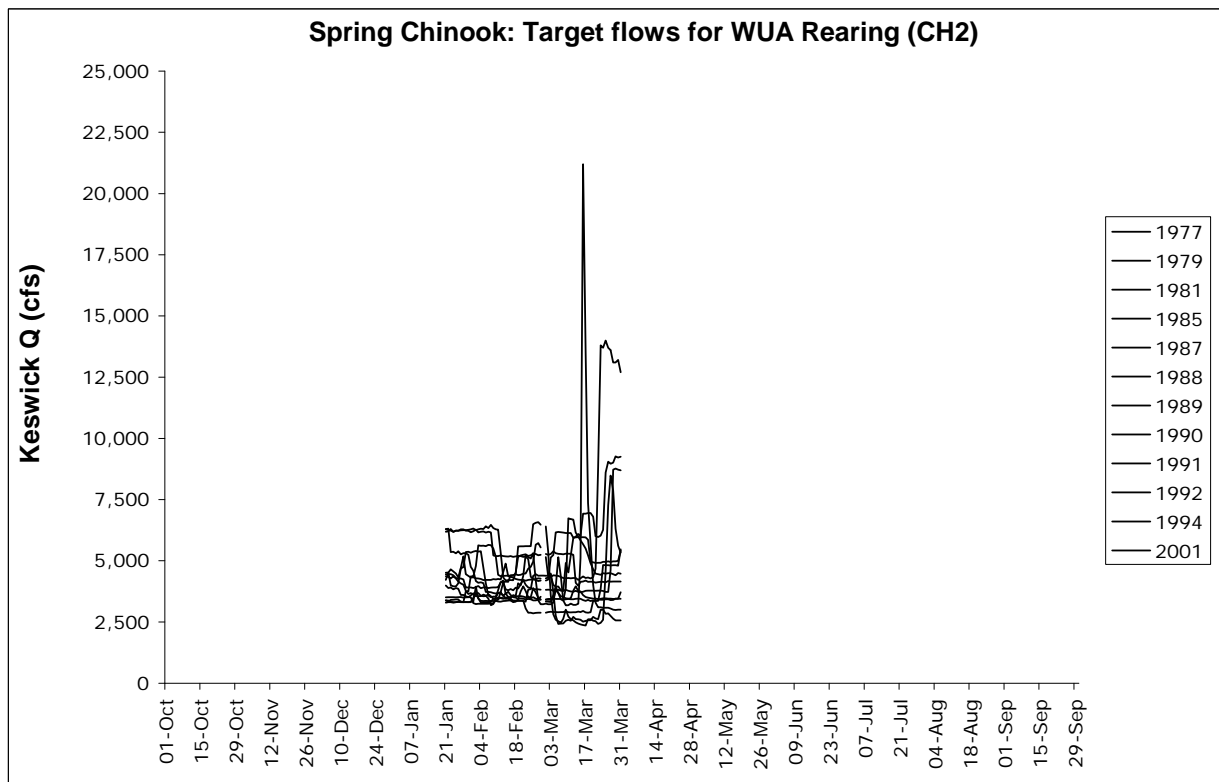
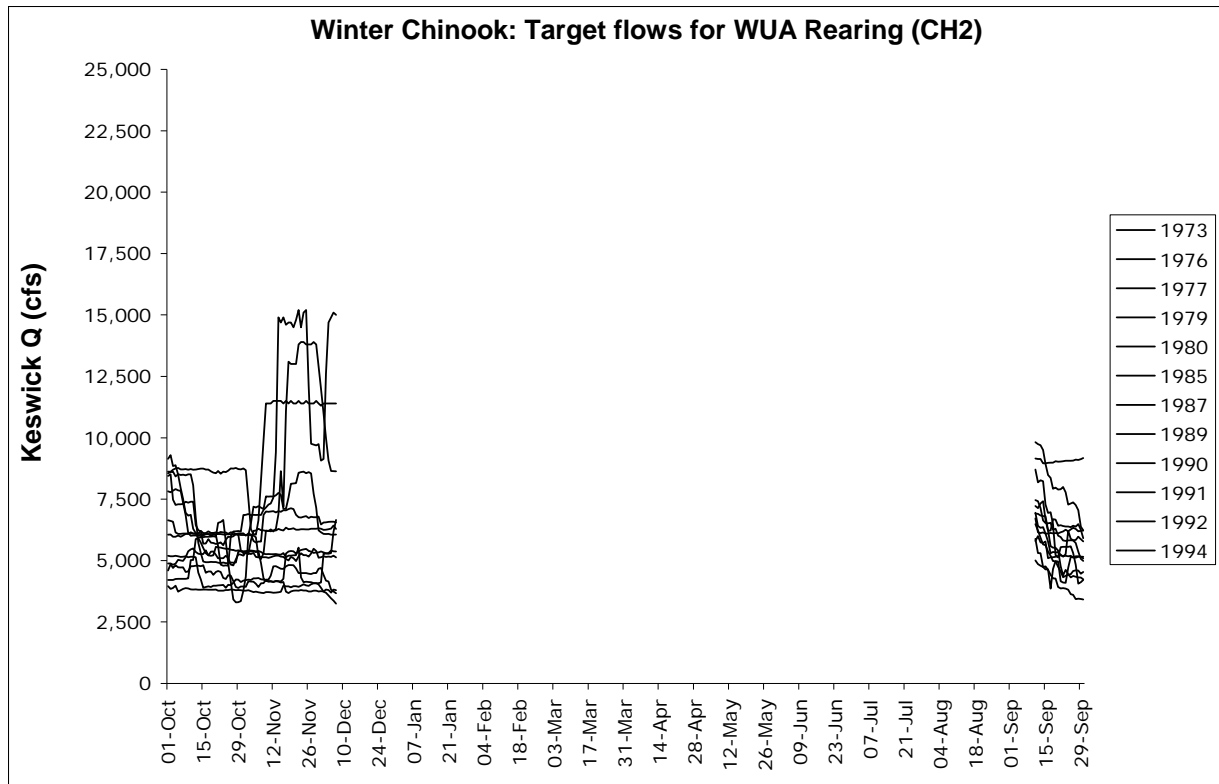


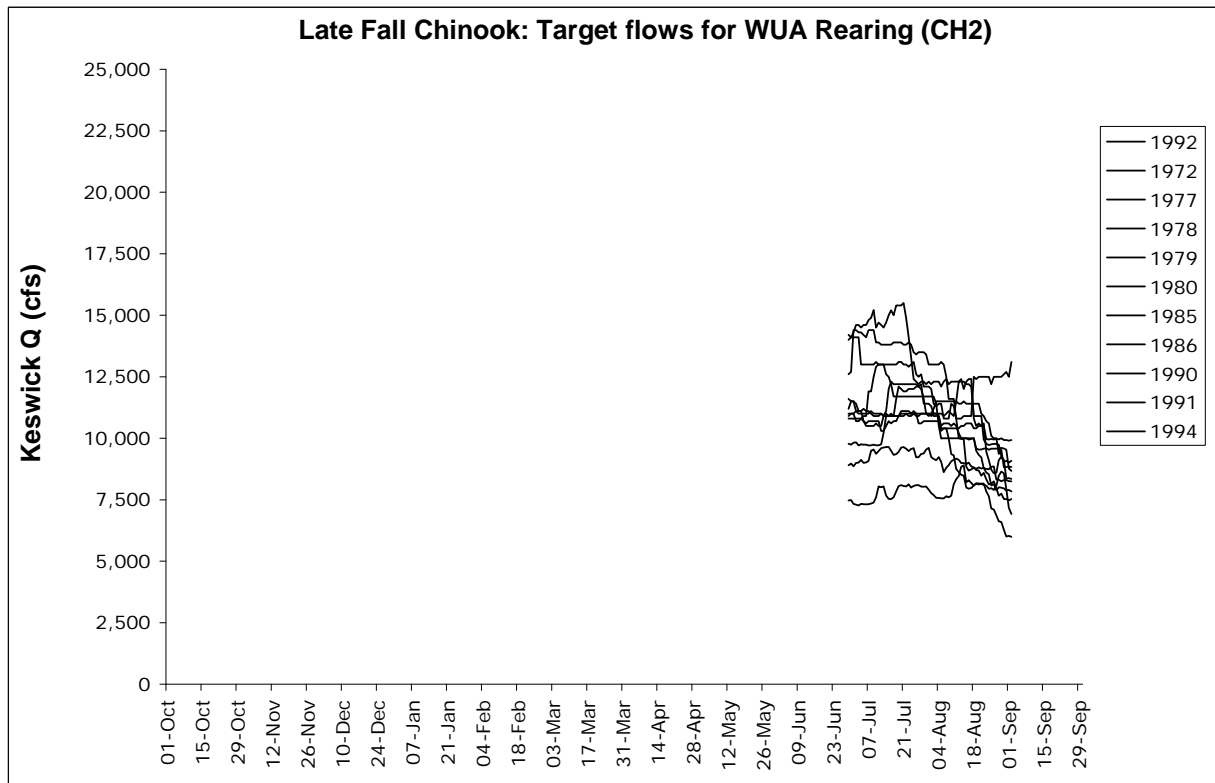
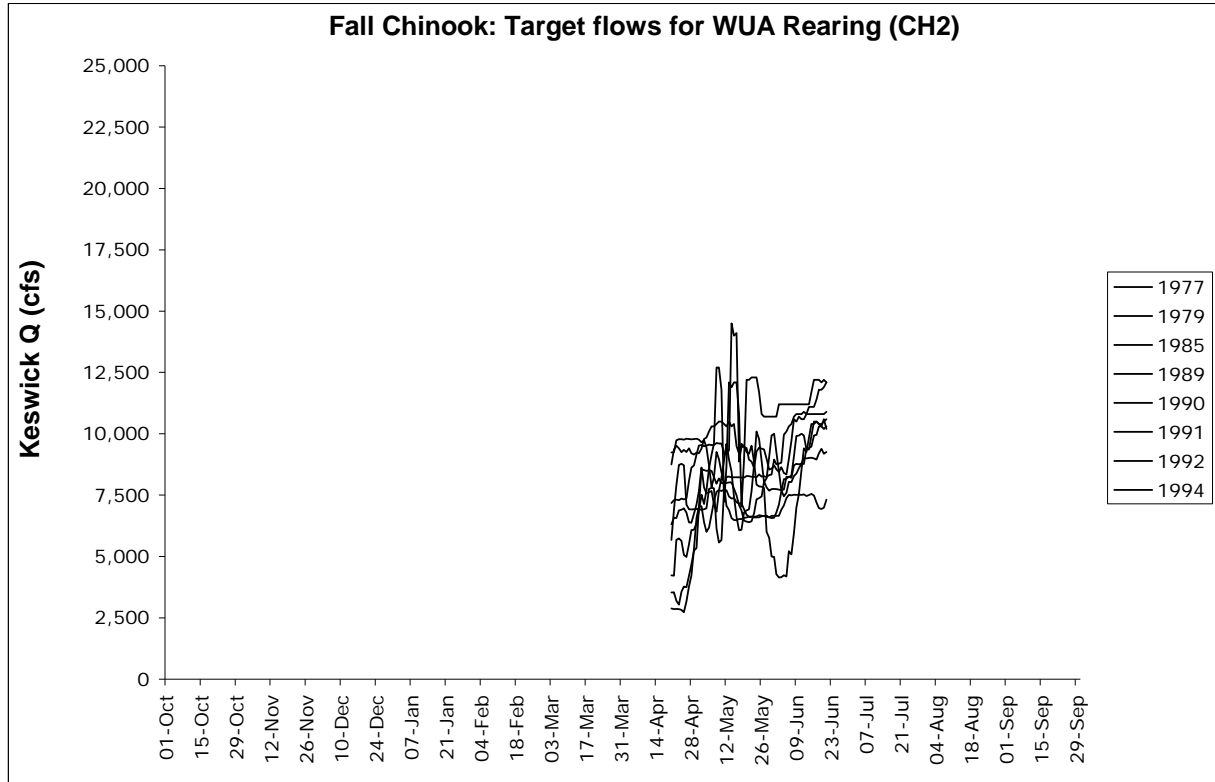


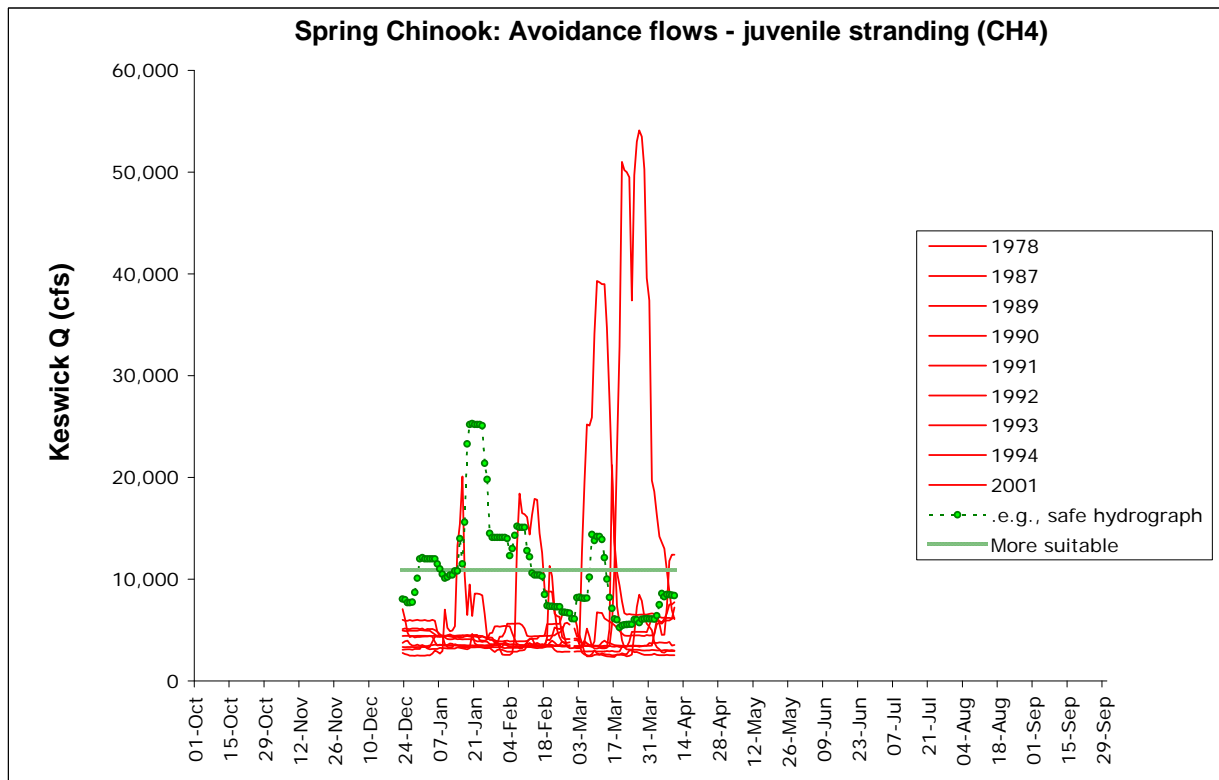
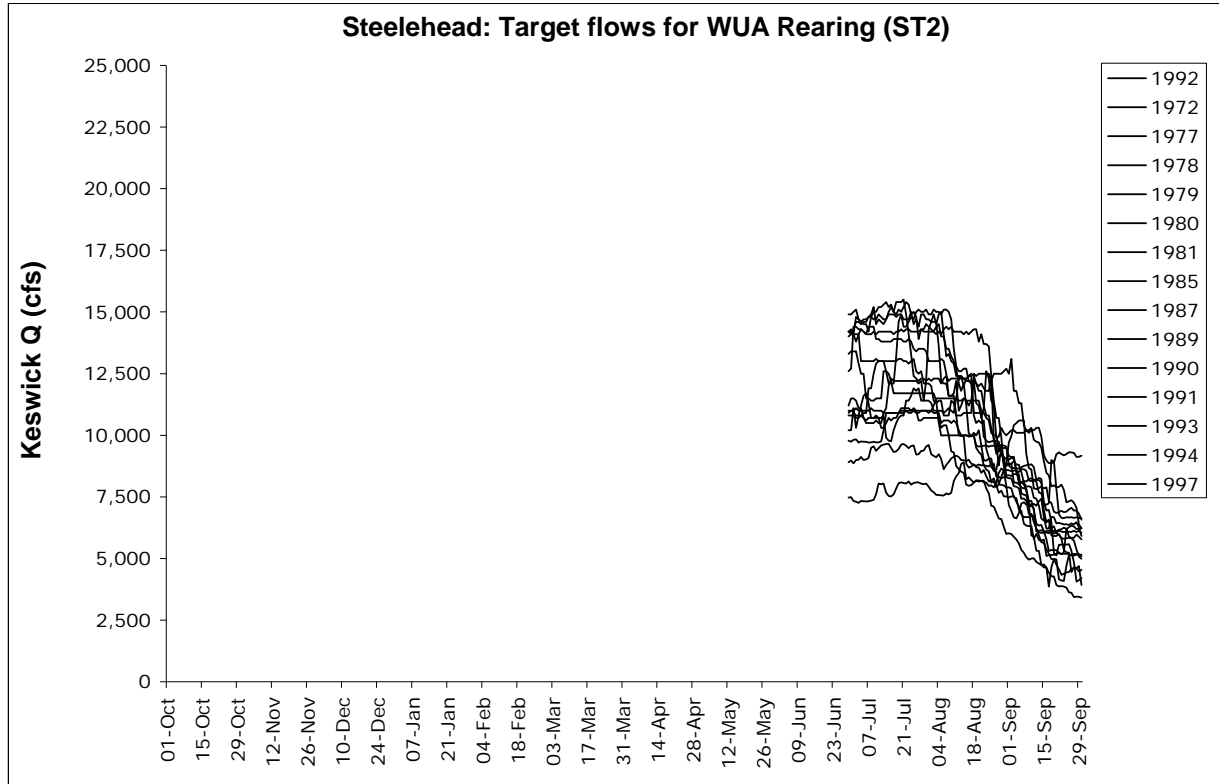


SacEFT - Chinook & Steelhead Redd Dewatering Report









SacEFT - Chinook & Steelhead Juvenile Stranding Report

